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EFFECTS OF DREDGING AND LAKEFILLING IN THE TORONTO WATERFRONT DURING 1984

Ontario
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Great Lakes Section
Water Resources Branch

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ABSTRACT

In 1984 the Great Lakes Section of the Ontario Ministry of the Environment continued investigations into the water and suspended particulate quality in the vicinity of dredging and lakefilling activities at the Toronto Harbour and East Headland (Leslie Street Spit), the Don River mouth, and the Toronto Main sewage treatment plant (Main STP) discharge. Surveys were undertaken in July, October, and November with samples being pumped from the depth of greatest turbidity for water quality analysis (physical parameters, nutrients, trace metals, trace organics) and from the surface (1.5 m) for analysis of suspended particulates collected with a centrifuge.

Water column turbidity profiling confirmed previous findings that surface turbidity was not a reliable indicator of subsurface conditions. The behaviour of subsurface plumes was influenced by thermal conditions in the Inner Harbour and by waves in the vicinity of the East Headland. The maximum extent of turbidity plumes were observed to be approximately 1.8 km from the Don River and approximately 1.0 km from the lakefilling at the East Headland.

Direct effects of dredging and lakefilling on water quality were found to be localized and generally secondary to the effects of flows from the Don River and the Main sewage treatment plant. Lindane was detected at levels slightly in excess of the Provincial Water Quality Objective (PWQO) of 10 ng litre^{-1} in water samples from the lower Don River, and similar levels of lindane were found, along with 1,2,3,4 tetrachlorobenzene, dichlorvos, and mevinphos, in water sampled near the Main STP discharge. No trace organics were detected in water samples near the dredging or lakefilling operations.

Analysis of centrifuged particulates at five stations (near the Don river mouth, dredging and lakefilling activities, and the Main STP discharge) found detectable levels of trace metals (including arsenic, cadmium, chromium, copper, mercury, and lead) and nine organochlorine compounds. Three of these (PCB, HCB, and p,p-DDE) were detected at all stations, and seven (PCB, alpha-chlordane, gamma-chlordane, dieldrin, HCB, p,p-DDE, p,p-DDD) were detected in the turbidity plume from the lakefilling operation. These results identify the need for further investigation of sediment transport, and chemical characterization and bioassessment of suspended particulates input to the Toronto waterfront.

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1.0 INTRODUCTION

1.1 Background

Since 1980 the Great Lakes Section of the Ontario Ministry of the Environment (MOE) has conducted various investigations into the effects of dredging and lakefilling at the Toronto Harbour and East Headland (also known as the Leslie Street Spit) (Figure 1). Previous investigations (Griffiths 1980, Griffiths and Winiecki 1981, Griffiths 1983, Boyd and Griffiths 1985) have found that short-term effects of dredging and lakefilling on surface water quality (as determined by sampling for physical parameters, nutrients and trace metals) were localized and generally subordinate to the influence of the Don River, and Main sewage treatment plant (STP) discharge (Figure 1). Varying frequencies were noted for violations of the Provincial Water Quality Objectives or guidelines (PWQO) near the Don R. mouth, the Main STP discharge, and near dredging and lakefilling activities for Total P (>90%), Cd (40-50%), Cu (15-95%), Fe (30-100%), Pb (0-25%) and Zn (0-15%). There was no indication of direct adverse impacts on recreational water use or drinking water supplies and the infrequent detection of trace organics could not be attributed to either dredging or lakefilling activity. Infrequent exceedances (0-30%) of the PWQO have been noted for dieldrin, lindane (gamma BHC), PCBs, and DDT and metabolites, primarily in the lower Don River and over the Main STP discharge.

The most recent publication describing the 1982/83 investigations (Boyd and Griffiths 1985), shows that surface turbidity was not a reliable indicator of subsurface conditions and that trace metals and organics such as As, Cd, Cr, Cu, Ni, Pb, Zn, alpha and gamma chlordane, PCBs, 2,4,5-trichlorophenoxyacetic acid (2,4,5 T), picloram, and silvex were adsorbed to suspended particulates in the vicinity of the East Headland.

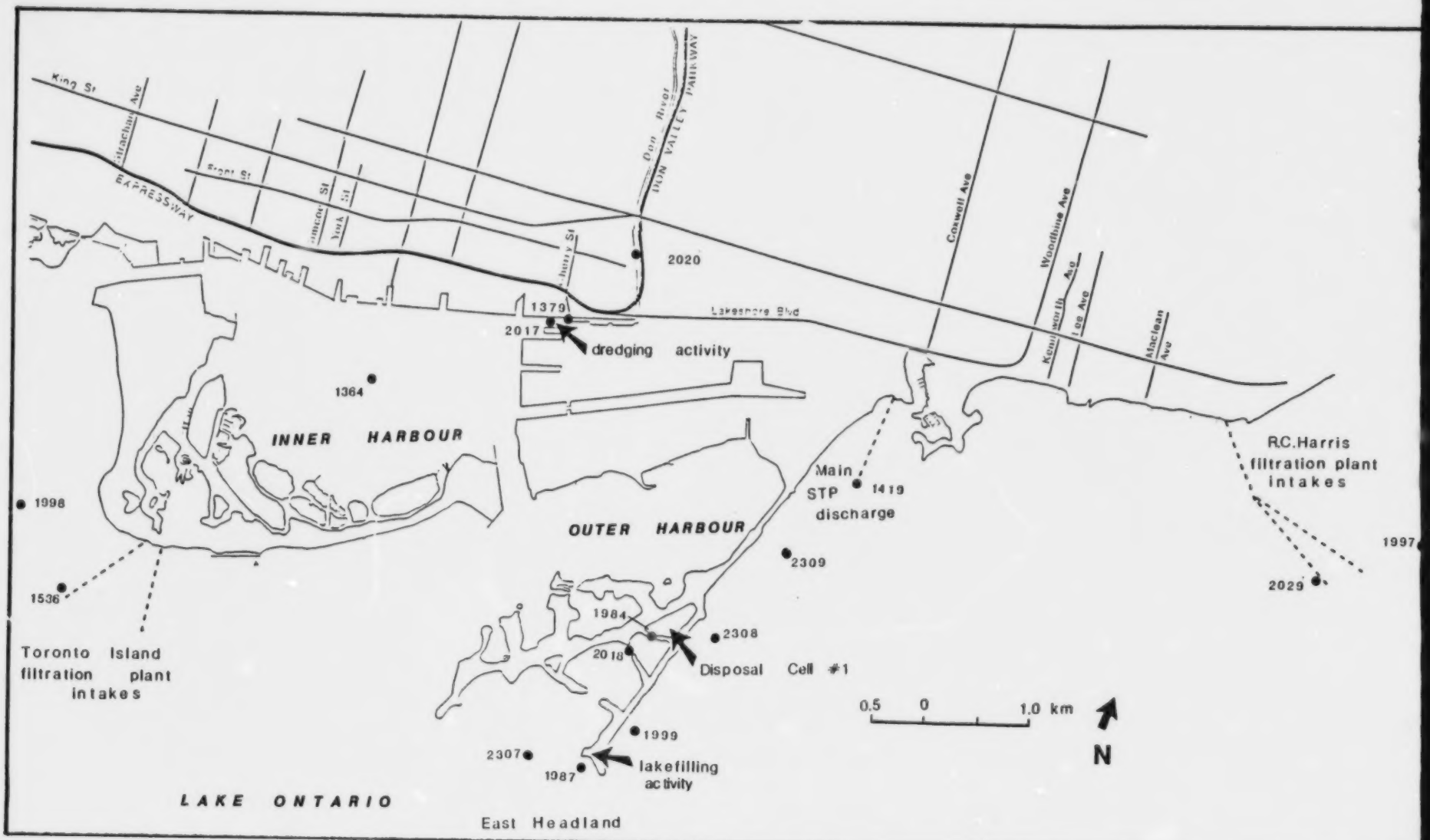


FIGURE 1 : Toronto Waterfront Study Area and Station Locations 1984

The quantity of dredged material disposed of at the East Headland endikement increased from 29,760 m^3 in 1983 to 83,335 m^3 in 1984, while the volume of lakefill material fell slightly from 895,430 m^3 to 779,303 m^3 (Toronto Harbour Commissioners 1984). Dredging operations in 1984 commenced in April and continued until December. More detailed information regarding the history of lakefilling at the East Headland, and annual dredging and lakefilling operations can be obtained from the Toronto Harbour Commissioners (THC). Information concerning the Provincial Lakefill Quality Assurance Programme (LQAP), designed to regulate the quality of fill material delivered to the East Headland, can be obtained from the Central Regional Office of MOE.

1.2 Objectives of 1984 Survey

The 1984 survey was designed to pursue preliminary findings from the 1982/83 work regarding turbidity plume tracking and the detection of contaminants associated with suspended particulates. The objectives were to:

(a) document water quality at the depth of greatest turbidity near source stations (Don River, dredge site, disposal site, lakefilling site and Main STP discharge), and at nearshore background stations; and

(b) identify contaminants associated with suspended particulates at source stations.

In the following report survey results have been summarized and presented in one section, and this has been followed by a separate discussion section. The report concludes with recommendations for further investigations necessary to address emerging concerns regarding the Toronto waterfront area.

2.0 MATERIALS AND METHODS

2.1 Survey Description

Water quality sampling for physical parameters, nutrients, trace metals and trace organics (see Appendix A for complete parameter list) was undertaken at 16 locations across the waterfront (Figure 1, Table 1) in the 1984 survey. Sampling for suspended particulates was also undertaken at five source stations (Figure 1, Table 2) for selected physical parameters, nutrients, trace metals, and trace organics (see Appendix B for complete parameter list).

Each episode of water quality sampling obtained three successive replicates from the depth of maximum turbidity at each of the station locations. This allowed a quantitative comparison of water chemistry results between stations from the depth where the greatest concentration of contaminants (associated with suspended particulates) was likely to occur. These results were, therefore, assumed to represent the "worst case" at the time of sampling for each location. Water quality sampling dates and locations are summarized in Table 3. Single suspended particulate samples were obtained from a depth of 1.5 m at each sampling location due to equipment limitations. Sampling dates and locations are summarized in Table 4.

In addition to water quality sampling, turbidity and temperature profiles were obtained over a 250 m grid in the northeast corner of the Inner Harbour, and in the vicinity of lakefilling at the East Headland. These results provided a means of describing the behaviour of turbidity plumes from the Don River and East Headland under a range of environmental conditions.

TABLE 1
1984 TORONTO WATERFRONT WATER QUALITY SAMPLING LOCATIONS

NUMBER	DESCRIPTION
2020	Don River south of Eastern Avenue (sampled from old rail bridge)
1379	mouth of Keating Channel at Cherry St. bridge (2m)
2017	moveable station at dredge location (5-10m)
1364	background station in Inner Harbour (9m)
1536	western intake of Toronto Island filtration plant (7m)
1987	moveable station at lakefilling location (10-15m)
1999	control station 500 m north of lakefilling (15m)
2307	control station 500 m southwest of lakefilling (15m)
1984	at the mouth of disposal Cell #1 (7m)
2018	at mouth of disposal Cell #2 (9m)
2308	Main STP to lakefilling transect control #1 (if STP plume is flowing along headland to the SE) (11m)
2309	Main STP to lakefilling transect control #2 (9m)
1419	over Main STP outfall (7m)
2029	over westen intake of R.C. Harris filtration plant(16m)
1998	control 1 km NW of Island f.p. intake (7m)
1997	control 1 km NE of R.C. Harris f.p. intake (16m)

TABLE 2
1984 TORONTO WATERFRONT CENTRIFUGED PARTICULATE SAMPLING LOCATIONS
(SOURCE STATIONS)

NUMBER	DESCRIPTION
1379	mouth of Keating Channel at Cherry St. bridge
2017	moveable station at dredge location
1987	moveable station at lakefilling location
1984	at the mouth of disposal Cell #1
1419	over Main STP outfall

TABLE 3
1984 TORONTO WATERFRONT SAMPLING LOCATIONS, DATES, AND DEPTHS

DATES	STATIONS															
	2020	1379	2017	1364	1998	1536	2307	1987	1999	2018	1984	2308	2309	1419	2029	1997
July 11	0.5 m	1.0 m	-	1.5 m	-	-	-	-	-	-	-	-	-	-	-	-
July 12	-	-	-	-	2.0 m	1.0 m	9.0 m	10.0 m	10.0 m	3.0 m	5.0 m	10.5 m	9.0 m	1.0 m	4.0 m	4.0 m
July 24	0.5 m	1.0 m	1.0 m	5.0 m	-	-	-	-	-	-	-	-	-	-	-	-
July 25	-	-	-	-	3.5 m	3.0 m	7.0 m	5.0 m	7.0 m	2.5 m	1.0 m	11.0 m	7.0 m	1.0 m	9.0 m	9.0 m
Oct. 11	0.5 m	1.0 m	7.0 m	1.5 m	-	-	-	-	-	-	-	-	-	-	-	-
Oct. 16	-	-	-	-	3.0 m	16.0 m	11.0 m	3.0 m	12.0 m	1.0 m	1.0 m	10.0 m	7.5 m	2.0 m	3.0 m	3.0 m
Nov. 27	-	-	-	-	1.5 m	1.5 m	4.0 m	8.0 m	10.0 m	4.0 m	5.0 m	4.0 m	4.0 m	3.0 m	1.5 m	1.5 m
Nov. 28	0.5 m	1.5 m	-	1.5 m	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 4
1984 TORONTO WATERFRONT CENTRIFUGED PARTICULATE
SAMPLING LOCATIONS AND DATES

STATIONS				
1379	2017	1984	1987	1419
July 11	July 24	July 25	July 25	July 26
July 24	Oct. 11	Oct. 12	Oct. 23	Oct. 20
Oct. 11	Nov. 29	Oct. 15	Oct. 24	Dec. 1
Nov. 28		Nov. 27	Nov. 30	

2.2 Field Methods

Water quality samples were pumped from the desired depth through teflon hose by means of a March 5C MD submersible pump. Sample containers were filled, preserved (where necessary), and stored according to MOE analytical methods, for the required range of tests (Ontario Ministry of the Environment 1983). Field blanks for metals and organics analysis were obtained by pouring double distilled H_2O through the pump-hose system.

Suspended particulates were pumped from a depth of 1 m through teflon hose by means of a March 5C MD submersible pump, and concentrated with a continuous flow Alfa Laval 103B centrifuge at a rate of approximately 6 litres per minute. The collected particulates were transferred to appropriate containers with a stainless steel scraper and stored for the desired analysis according to MOE analytical methods (Ontario Ministry of the Environment 1983).

Depth profiles of temperature and percentage transmittance (a measure of turbidity) were obtained with a Moniteq MTR 25 transmissometer package (containing a 25 cm path-length transmissometer calibrated to 75% in air, a temperature probe, a pressure transducer, and an X-Y chart recorder). Continuous turbidity profiles were recorded while lowering the sonde; temperature tracings were obtained while raising the sonde.

2.3 Laboratory Methods

Water quality analyses were undertaken by the Water Quality Section, Inorganic Trace Contaminant Section, and Drinking Water Organics Section at the Laboratory Services Branch according to procedures outlined in MOE analytical methods (Ontario Ministry of the Environment 1983). Suspended particulates were submitted to the Inorganic Trace Contaminants Section, and the Trace Organics Section at the Laboratory Services Branch for analysis according to standard MOE analytical methods.

3.0 RESULTS

3.1 Turbidity Profiling

Results of turbidity profiling in the Inner Harbour and near the East Headland have been summarized (Tables 5; 6) along with pertinent environmental data. Precipitation and wind information were obtained from Environment Canada (1984), with the wind summary for the dates in question based on hourly wind record results from 0800 hours to 1600 hours at the Toronto Island meteorological station.

Delineation of turbidity plume extent from rivers or lakefilling activities is extremely difficult in the nearshore zone, given the inherent variability in background turbidity levels resulting from other sources such as STP discharges, shoreline erosion, and resuspension of bed sediments. Although arbitrary criteria can be set to differentiate between a diffuse turbidity plume from a point source and background turbidity from other sources, this does not yield a truly quantitative assessment.

In this instance the interpretation was based on the shape of the profile in combination with a derived value of 35% transmittance as the minimum water clarity (i.e. maximum turbidity) which could be considered characteristic of background conditions. Any distinct difference (assuming a reading error of $\pm$ 5% transmittance) in water clarity with depth was considered evidence of some source of turbidity, and any reading of less than 35% transmittance was considered indicative of turbidity in excess of background levels. This percentage number was derived during a separate calibration test for the specific equipment being used along the Toronto nearshore area (excluding zones near STP discharges) as being typical of suspended particulate concentrations of approximately 2 to 3 mg litre^{-1}: a concentration of suspended particulates which is rarely exceeded at background stations.

TABLE 5
TURBIDITY PLUME TRACKING SUMMARY FOR INNER HARBOUR

DATE	PRECIPITATION	WIND	TEMP. PROFILE	TURBIDITY PLUME
July 11, 1984	4.8 mm on July 10, trace amount on July 11	SSW-NW 2-30 Km h^{-1}	6°C near bed 13.5°C at surface	No dredging. Warm turbid flow from Don River resulting in surface plume confined to NE corner of harbour, approx. 1.5 Km from Cherry St. bridge.
July 24, 1984	None	N-W 17-33 Kmh^{-1}	8°C near bed 13.5°C at surface	Dredging plume not distinguishable from Don River. Warm turbid flow from Don resulting in surface plume approx. 1 km from Cherry St. bridge. Diffuse sinking plume towards east of harbour 0.6 Km beyond surface plume.
Oct. 11, 1984	None	N,W, & S 11-4 Kmh^{-1}	9.5°C near bed 11°C at surface	Dredging plume not distinguishable from Don River. Highly turbid subsurface plume confined to NE corner, approx. 1 Km from Cherry St. bridge along north wall.
Nov. 28, 1984	1.6 mm on Nov. 28	ESE, S, SSW 35-19 Kmh^{-1}	5.5°C bed to surface	Dredging at Cherry St. bridge, no separate dredging plume. Sinking plume extending from NE corner to Eastern Gap 1.8 Km from Cherry St. bridge.

TABLE 6
TURBIDITY PLUME TRACKING SUMMARY FOR EAST HEADLAND

DATE	WIND	CURRENT	TEMP. PROFILE	TURBIDITY PLUME
July 12, 1984	S-W 6-30 Kmh^{-1} fairly calm (i.e. waves <0.5 m)	to ESE at surface, to SSW subsurface	6.5°C near bed 9°C at surface	Rapidly sinking plume from lakefill 0.1 Km to SSW surface plume to ESE, current reversal may be in progress. Turbidity slightly higher near surface than bed at background station.
July 25, 1984	E-S 11-6 Kmh^{-1} very calm (i.e. surface ripples only)	to SW	7.5°C near bed 14°C at surface	Localized sinking plume from lakefill 0.4 Km to W. Turbidity slightly greater near bed than surface at background station.
Oct. 16, 1984	ENE 17-30 Kmh^{-1} 1m swell from east	to SW, 28 cm s^{-1} at 11m depth	12.5°C bed to surface	Surface plume at lakefill (due to wave action), sinking plume observed 0.7 Km to S and SW, extending 0.5 Km north. Resuspension in shallow water along eastern face of endikement appears to be taking place. Uniform turbidity profile at background station.
Oct. 27, 1984	E, 15-26 Kmh^{-1} <1m swell from east	to S, 4 cm s^{-1} at 8m depth	5°C bed to surface	Subsurface plume at lakefill extending 0.4 Km to SW. Uniform turbidity profile at background station.

Results for the Inner Harbour (Table 5) demonstrate that turbidity plumes arising from dredging activity could not be distinquished from the effects of the Don River except in the immediate vicinity of the dredge site. They also show that the maximum extent of this plume, when tracked below the surface, was approximately 1.8 km across the eastern portion of the harbour into the Eastern Gap.

The (virtually) simultaneous acquisition of temperature and turbidity profiles provided the means to demonstrate the effect of thermal conditions on plume behaviour. Results obtained on 11 July (Figure 2) clearly show the warm turbid flow from the Don River overlying the cooler water of the harbour.

Profiling results from the vicinity of the East Headland (Table 6) show the general tendency for plumes to have become submerged down-range from the lakefilling site, even when wave action created a surface plume in the immediate vicinity of the lakefill site (station 1987) on 16 October (Figure 3). It is also apparent that during relatively calm conditions even three-dimensional plume tracking could not discern turbidity greater than the assumed background level beyond 0.5 km from the lakefilling site.

During the relatively stormy conditions experienced on 16 October 1984 the subsurface plume from the lakefill site was tracked in the direction of the lake current (i.e. approximately NE to SW) to a distance of 0.7 km. However, a subsurface plume was also observed 0.5 km to the north at station 1999 (Figure 3) and a steep turbidity gradient was detected 1.5 km to the north at station 2308.

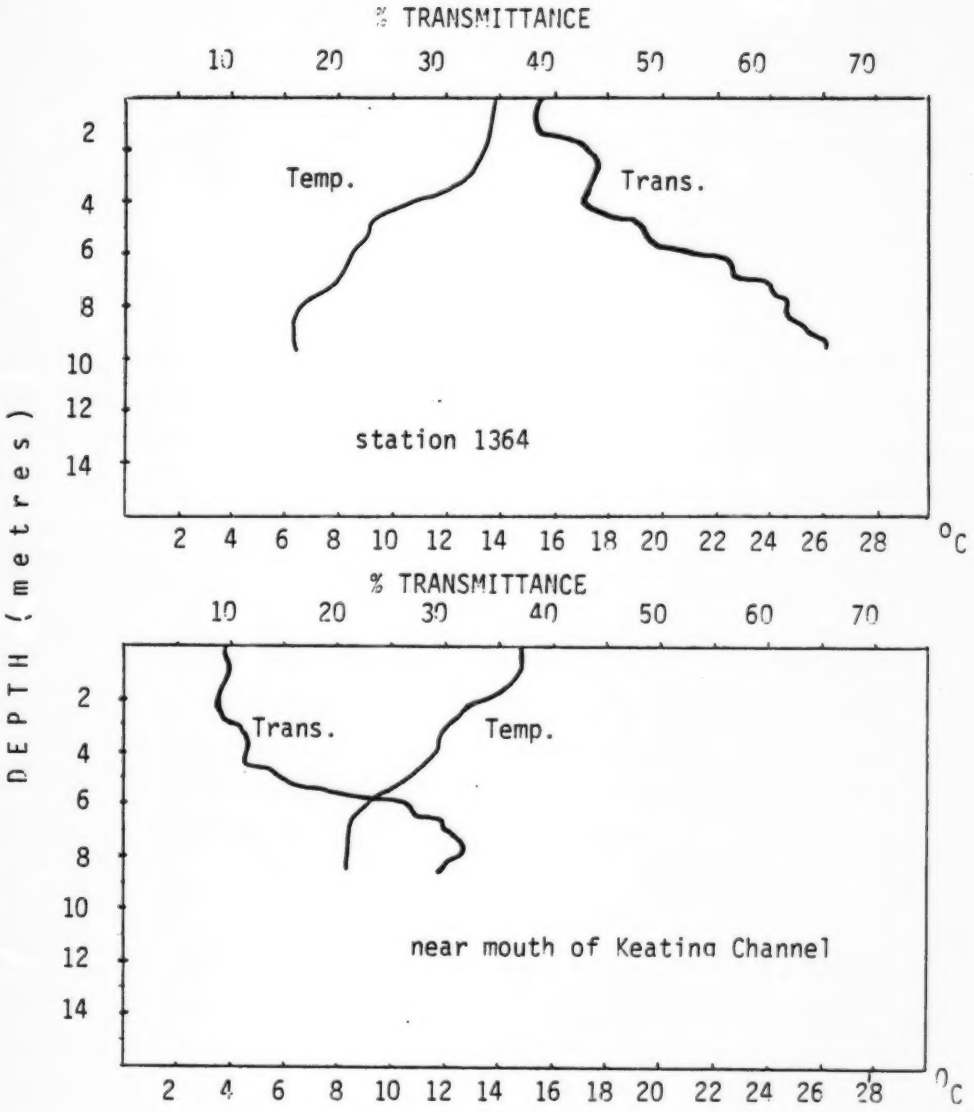


FIGURE 2: Turbidity and Temperature Profiling Results from the Inner Harbour, 11 July 1984

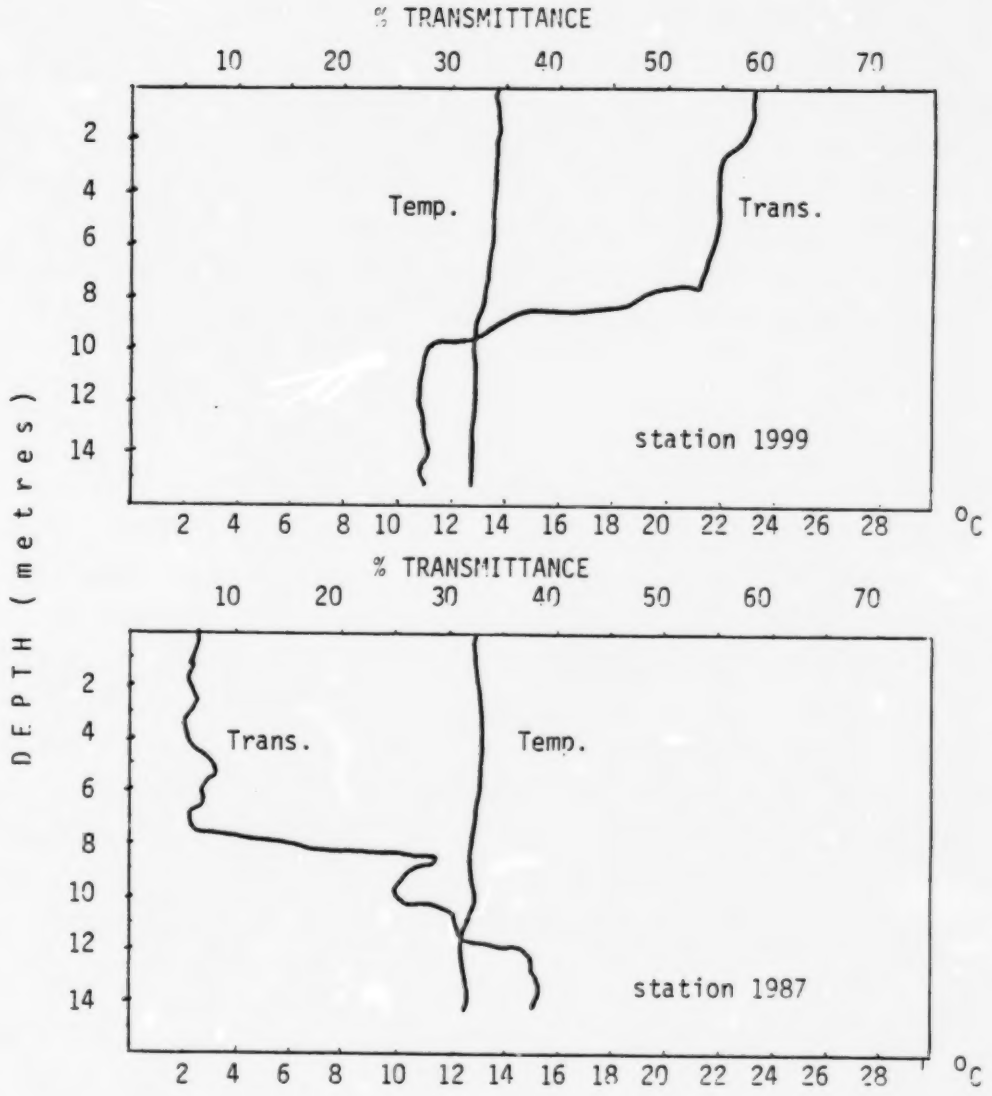


FIGURE 3: Turbidity and Temperature Profiling Results from near the East Headland, 16 October 1984

Turbidity conditions at background stations (stations 1997, 1998) showed some dependence on thermal conditions. During the two July surveys, under stratified conditions (maximum temperature gradient of approximately 1.3°C per metre depth), turbidity profiles exhibited variation from bed to surface; no such variation was present under isothermal conditions in October and November. July results differed from each other in that surface turbidity slightly exceeded subsurface turbidity on 12 July, whereas the opposite situation occurred on 25 July.

3.2 Water Quality

Results for various physical tests, nutrients, and trace metals have been summarized (Tables 7 to 16) to show the percentage of results greater than (a) the minimum reportable amount (MRA), and (b) the Provincial Water Quality Objectives (PWQO) for the protection of aquatic life and recreation (Ontario Ministry of the Environment 1984). These summary tables also list the median, mean and standard deviation for each parameter. Results for organochlorine, organophosphorus and chlorobenzene compounds have been listed (Table 17) for the two stations and four compounds which yielded results greater than the MRA. Appendix A lists the fifty-seven tests performed on water samples.

TABLE 7

1984 EFFECTS OF DREDGING/LAKEFILLING

WATER QUALITY SUMMARY - Conductivity 25°C

Parameter: Cond. 25 (uS/cm) Minimum Reportable Amount: 0.3 (uS/cm) PWQO: --

	STATIONS															
	2020	1379	2017	1364	1998	1536	2307	1987	1999	2018	1984	2308	2309	1419	2029	1997
Sample Size	9	9	6	9	12	12	12	12	12	12	12	12	12	12	12	12
% > MRA	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
% > PWQO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maximum	1035	648	427	375	339	337	331	349	345	335	331	352	340	486	331	332
Minimum	920	405	389	295	315	315	328	315	331	325	330	330	325	361	320	320
Median	990	444	418.5	350	329	330.5	330	340	337	330	330	338.5	332.5	407	327	327.5
Mean	981.9	483.9	413.2	348.2	328.5	327.9	329.3	322.8	337.9	330.2	330.4	339.0	331.6	423.1	326.3	326.9
Stnd. Dev.	47.7	89.1	15.5	24.2	8.4	8.8	1.1	11.1	3.4	3.6	0.5	7.3	5.8	43.7	4.5	4.6

TABLE 8

1984 EFFECTS OF DREDGING/LAKEFILLING

WATER QUALITY SUMMARY - Turbidity

Parameter: Turbidity (FTU) Minimum Reportable Amount: 0.42 (FTU) PWQO: --

	STATIONS															
	2020	1379	2017	1364	1998	1536	2307	1987	1999	2018	1984	2308	2309	1419	2029	1997
Sample Size	9	9	6	9	12	12	12	12	12	12	12	12	12	12	12	12
% > MRA	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
% > PWQO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maximum	16.6	14.1	22.0	5.8	3.1	1.9	4.8	33.0	9.9	6.7	24.0	4.8	8.4	11.5	4.1	4.5
Minimum	4.3	8.4	6.8	1.2	1.1	1.1	1.1	1.6	2.1	2.7	1.4	1.6	1.4	2.2	0.8	1.0
Median	6.3	11.3	13.7	2.8	1.7	1.3	2.1	18.6	3.1	4.1	17.5	4.0	3.2	5.7	1.7	1.9
Mean	9.28	11.34	13.90	2.77	1.82	1.57	2.61	18.99	3.77	4.47	14.75	3.54	3.80	6.28	1.98	2.29
Stnd. Dev.	4.90	2.08	6.51	1.44	0.70	0.70	1.38	11.34	2.15	1.35	8.45	1.16	2.16	2.97	1.03	1.28

TABLE 9

1984 EFFECTS OF DREDGING/LAKEFILLING

WATER QUALITY SUMMARY - Total Phosphorus

Parameter: Total P (ug/L) Minimum Reportable Amount: 9 (ug/L) PWQO: 20 (guideline) (ug/L)

	STATIONS															
	2020	1379	2017	1364	1998	1536	2307	1987	1999	2018	1984	2308	2309	1419	2029	1997
Sample Size	9	9	6	9	12	12	12	12	12	12	12	12	12	12	12	12
% > MRA	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
% > PWQO	100	100	100	66.7	25	75	16.7	91.7	50	16.7	75	83	75	100	0	8.3
Maximum	1028	93	74	53	36	43	23	78	57	24	82	45	30	320	19	27
Minimum	106	58	36	12	9	5	9	16	12	13	10	20	9	58	7	6
Median	205	79	57	29	15	14	11	46	29	17	41	23	24	122	11	12
Mean	250.1	78.8	55.8	30.0	17.5	18.8	13.7	46.7	29.2	17.8	43.8	26.4	21.6	143.6	11.8	12.6
Stnd. Dev.	128.1	12.1	18.2	16.1	8.4	12.4	5.5	18.4	15.5	3.5	25.9	7.7	7.8	91.2	3.8	5.4

TABLE 10

1984 EFFECTS OF DREDGING/LAKEFILLING

WATER QUALITY SUMMARY - Total Kjeldahl Nitrogen

Parameter: Total Kjeldahl N (ug/L) Minimum Reportable Amount: 88 (ug/L) PWQO: --

	STATIONS															
	2020	1379	2017	1364	1998	1536	2307	1987	1999	2018	1984	2308	2309	1419	2029	1997
Sample Size	9	9	6	9	12	12	12	12	12	12	12	12	12	12	12	12
% > MRA	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
% > PWQO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maximum	4600	2450	1130	640	660	490	510	880	980	380	510	830	570	7500	340	490
Minimum	1450	640	310	360	200	280	160	340	390	260	190	350	260	1520	120	120
Median	3900	790	840	420	320	330	290	445	590	340	440	530	375	3900	305	300
Mean	3332.2	1335.6	808.3	466.7	357.5	360.8	315.8	525.0	661.6	328.3	393.3	561.7	409.2	4468.3	265.8	287.7
Stnd. Dev.	1416.2	819.5	356.7	106.3	135.3	78.1	127.0	187.8	199.8	40.0	111.8	163.5	118.0	2307.0	90.8	101.9

TABLE 11

1984 EFFECTS OF DREDGING/LAKEFILLING

WATER QUALITY SUMMARY - Arsenic

Parameter: As (ug/L) Minimum Reportable Amount: 1 (ug/L) PWQO: 100 (ug/L)

	STATIONS															
	2020	1379	2017	1364	1998	1536	2307	1987	1999	2018	1984	2308	2309	1419	2029	1997
Sample Size	9	9	6	9	12	12	12	12	12	12	12	12	12	12	12	12
% > MRA	33.3	33.3	50	33.3	33.3	25	8.3	33.3	0	16.7	33.3	25	33.3	50	41.7	71.4
% > PWQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	1	1	1	1	1	1	1	1	<1	1	1	1	1	1	1	1
Minimum	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Median	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Mean	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stnd. Dev.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 12

1984 EFFECTS OF DREDGING/LAKEFILLING

WATER QUALITY SUMMARY - Cadmium

Parameter: Cd (ug/L) Minimum Reportable Amount: 0.2 (ug/L) PWQO: 0.2 (ug/L)

	STATIONS															
	2020	1379	2017	1364	1998	1536	2307	1987	1999	2018	1984	2308	2309	1419	2029	1997
Sample Size	9	9	6	9	12	12	12	12	12	12	12	12	12	12	12	12
% > MRA	44.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
% > PWQO	44.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0.6	<0.3	<0.3	<0.3	<0.3	<0.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Minimum	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Median	<0.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Mean	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stnd. Dev.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 13

1984 EFFECTS OF DREDGING/LAKEFILLING

WATER QUALITY SUMMARY - Chromium

Parameter: Cr (ug/L) Minimum Reportable Amount: 1,2 (variable) (ug/L) PWQO: 100 (ug/L)

	STATIONS															
	2020	1379	2017	1364	1998	1536	2307	1987	1999	2018	1984	2308	2309	1419	2029	1997
Sample Size	9	9	6	9	11	12	12	12	12	12	11	12	11	12	12	12
% > MRA	100	100	100	100	72.7	75	91.7	91.7	83.3	100	100	75	73	100	75	75
% > PWQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	38	11	6	3	2	5	3	4	3	6	6	3	3	9	3	3
Minimum	8	3	3	2	1	<1	<1	<1	<1	1	2	<1	<1	3	<1	<1
Median	15	6	5	3	2	2	2	3	3	2	3	2	2	4	2	2
Mean	13.4	6.7	4.7	2.6	-	-	-	-	-	2.3	3.2	-	-	4.9	-	-
Stnd. Dev.	4.3	3.0	1.2	0.5	-	-	-	-	-	1.4	1.3	-	-	2.2	-	-

TABLE 14

1984 EFFECTS OF DREDGING/LAKEFILLING

WATER QUALITY SUMMARY - Filtered Mercury

Parameter: Hg (ug/L) (filtered) Minimum Reportable Amount: 0.01 (ug/L) PWQO: 0.2 (ug/L)

	STATIONS															
	2020	1379	2017	1364	1998	1536	2307	1987	1999	2018	1984	2308	2309	1419	2029	1997
Sample Size	9	12	6	12	12	12	12	12	12	12	12	12	12	12	12	12
% > MRA	77.8	83.3	50	75	58.3	75	50	75	83.3	58.3	75	66.7	58.3	58.3	58.3	58.3
% > PWQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0.04	0.03	0.0	0.05	0.04	0.05	0.07	0.06	0.05	0.05	0.05	0.05	0.04	0.06	0.05	0.05
Minimum	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Median	0.04	0.02	0.01	0.02	0.01	0.01	0.01	0.03	0.03	0.01	0.02	0.03	0.02	0.03	0.02	0.02
Mean	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stnd. Dev.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 15

1984 EFFECTS OF DREDGING/LAKEFILLING

WATER QUALITY SUMMARY - Lead

Parameter: Pb (ug/L) Minimum Reportable Amount: 3 (ug/L) PWQO: 25 (variable) (ug/L)

	STATIONS															
	2020	1379	2017	1364	1998	1536	2307	1987	1999	2018	1984	2308	2309	1419	2029	1997
Sample Size	9	9	6	9	12	12	12	12	12	12	12	12	11	12	12	12
% > MRA	77.8	100	83.3	0	0	25	0	25	0	0	75	0	0	0	0	0
% > PWQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	11	7	7	<3	<3	5	<3	6	<3	<3	9	<3	<3	<3	<3	<3
Minimum	<3	4	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Median	6	5	5	<3	<3	<3	<3	<3	<3	<3	6	<3	<3	<3	<3	<3
Mean	-	5.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stnd. Dev.	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 16

1984 EFFECTS OF DREDGING/LAKEFILLING

WATER QUALITY SUMMARY - Zinc

Parameter: Zn (ug/L) Minimum Reportable Amount: 1 (ug/L) PWQO: 30 (ug/L)

	STATIONS															
	2020	1379	2017	1364	1998	1536	2307	1987	1999	2018	1984	2308	2309	1419	2029	1997
Sample Size	9	9	6	9	12	12	12	12	12	12	12	12	11	12	12	12
% > MRA	100	100	100	100	83.3	75	83.3	91.7	75	75	100	75	72.7	100	75	66.7
% > PWQO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	26	13	12	6	2	7	6	10	4	4	12	5	3	9	4	2
Minimum	9	7	5	2	<1	<1	<1	<1	<1	<1	1	<1	<1	3	<1	<1
Median	24	12	8	2	2	2	2	4	3	3	8	2	2	5	1	1
Mean	20.4	10.1	8.2	3.0	-	-	-	-	-	-	7.2	-	-	5.4	-	-
Stnd. Dev.	6.3	1.1	3.2	1.4	-	-	-	-	-	-	4.3	-	-	2.1	-	-

TABLE 17
1984 EFFECTS OF DREDGING/LAKEFILLING
WATER QUALITY SUMMARY - Trace Organics (ng/L)
(These results have not been confirmed with duplicate analyses)

STATION 1419						STATION 1379		
DATE	DEPTH (m)	1,2,3,4 TETRACHLOROBENZENE*	DICHLORVOS **	MEVINPHOS **	gamma BHC*	DATE	DEPTH (m)	gamma BHC*
12/07/84	1.0	ND	-	-	ND	11/07/84	1.0	ND
	1.0	ND	ND	ND	ND		1.0	ND
	1.0	ND	-	-	ND		1.0	ND
25/07/84	1.0	11	-	-	ND	24/07/84	1.0	ND
	1.0	ND	ND	ND	ND		1.0	15
	1.0	ND	-	-	ND		1.0	ND
16/10/84	2.0	ND	500	140	ND	11/10/84	1.0	12
	2.0	ND	-	-	ND		1.0	14
	2.0	ND	-	-	ND		1.0	16
27/11/84	3.0	-	ND	ND	12	28/11/84	1.5	ND
	3.0	-	-	-	ND		1.5	ND
	3.0	-	-	-	15		1.5	ND

"ND" = not detected, " - " = not sampled
"*" = minimum reportable amount of 1 ng/L
"**" = minimum reportable amount of 10 ng/L

Note: only those compounds which were detected have been listed here - see Appendix A for complete parameter list

OBJECTIVES AND GUIDELINES

Compound	Description of Objective or Guideline
1,2,3,4-tetrachlorobenzene	Provincial Water Quality Objective of 100 ng/L
gamma-BHC (lindane)	Provincial Water Quality Objective of 10 ng/L
Dichlorvos	No Provincial Objective. Forty-eight hour LC_{50} for Daphnia magna of 70 ng/L
Mevinphos	No Provincial Objective. Forty-eight hour LC_{50} for fish ranging from 20×10^3 ng/L to 31.6×10^6 ng/L.

Note: Mevinphos is registered for agricultural use only and would not be expected to occur in an urban environment under normal circumstances. Dichlorvos, on the other hand, is a commonly used insecticide for fumigation in urban environments. Although mevinphos is highly toxic to mammals, and dichlorvos is moderately toxic (based on oral and/or dermal LD_{50} for rats), both substances are non-persistent (having a half-life of approximately 35 days) and are difficult to detect in the aquatic environment. The apparent detection of these compounds suggests that a spill may have occurred, although the lack of confirmation through duplicate analyses means that the possibility of incorrect identification as the result of chemical interference must also be considered. Future sampling at this location will ascertain whether detection of these non-persistent compounds at levels which may be acutely lethal to certain aquatic biota represents a serious concern.

3.2.1 Physical Parameters

Maximum conductivity results (Table 7) were obtained in the lower Don River (station 2020) with a median value of 990 uS cm^{-1} and a range of 115 uS cm^{-1}. The influence of the Don was also observable at the Cherry Street Bridge (station 1379) where a median result of 444 uS cm^{-1} was recorded. A median of 418.5 uS cm^{-1} was obtained at the moveable dredge site station in the northeast corner of the Inner Harbour (station 2017), diminishing to 350 uS cm^{-1} at the central Inner Harbour station (station 1364). Results obtained outside the Inner Harbour were generally uniform with medians ranging from 327.5 uS cm^{-1} at the eastern control station (station 1997) to 340 uS cm^{-1} near the lakefilling (station 1987), and ranges of less than 35 uS cm^{-1}. The only exception to these uniform findings was observed near the Main STP discharge (station 1419) where a median of 407 uS cm^{-1}, and a range of 125 uS cm^{-1} was recorded.

Increased turbidity results (Table 8) were also obtained in the lower Don River (station 2020), near the mouth of the Don (station 1379), and near the Main STP discharge (station 1419) with medians of 6.4 FTU, 11.3 FTU, and 5.7 FTU, respectively, and corresponding ranges of 12.3 FTU, 5.7 FTU and 9.3 FTU. In this case, however, the most extreme results were associated with dredging (station 2017), disposal (station 1984) and lakefilling (station 1987) activities with medians of 13.7 FTU, 17.5 FTU and 18.6 FTU, respectively. The ranges were greater at these stations also, varying from 15.2 FTU to 31.4 FTU. The harbour background station (station 1364) yielded a median of 2.8 FTU (4.6 FTU range) while medians outside the harbour were generally less than 4.0 FTU.

3.2.2 Nutrients

Inspection of total phosphorus and total Kjeldahl nitrogen results (see Appendix C) also suggested a significant degree of interaction between sampling period and station effects, so comparison of results between stations was restricted to medians and ranges.

Maximum total phosphorus results (Table 9) were recorded in the lower Don River (station 2020) with a median value of 205 ug litre^{-1} and a range of 922 ug litre^{-1}. Median results decreased to 79 ug litre^{-1} (range 35 ug litre^{-1}) at the Cherry Street bridge (station 1379), 57 ug litre^{-1} (range 38 ug litre^{-1}) at the dredge site (station 2017), and 29 ug litre^{-1} (range 41 ug litre^{-1}) at the central Inner Harbour site (station 1364). Outside the harbour, the maximum concentration was observed near the Main STP discharge (station 1419) with a median value of 122 ug litre^{-1} and a range of 262 ug litre^{-1}. Median concentrations of 15 ug litre^{-1} (range 27 ug litre^{-1}) and 12 ug litre^{-1} (range 21 ug/litre^{-1}) were recorded at the westerly and easterly control stations (stations 1998, 1997), with increased median levels of 46 ug litre^{-1} (range 62 ug litre^{-1}) and 41 ug litre^{-1} (range 72 ug litre^{-1}), respectively, at the lakefilling (station 1987) and disposal sites (station 1984). Median concentrations at other stations ranged from 11 ug litre^{-1} to 29 ug litre^{-1}.

Only the station near the R.C. Harris filtration plant intake (station 2029) met the Provincial 20 ug litre^{-1} guideline for the maintenance of nuisance-free concentration of algae in lakes (Ontario Ministry of the Environment 1984) for all samples. All results obtained in the lower Don River (station 2020), the northeast corner of the Inner Harbour (stations 1379, 2017), and near the Main STP discharge (station 1419) exceeded the 20 ug litre^{-1} guideline.

Maximum concentrations of total Kjeldahl nitrogen were detected in the lower Don River (station 2020) and near the Main STP discharge (station 1419) (Table 10). In both cases the median value was 3,900 ug litre^{-1}, although the Don River station had a range of 3,150 ug litre^{-1} compared with 5,980 ug litre^{-1} near the Main STP discharge. Median concentrations in the harbour were recorded to be 790 ug litre^{-1} (range 1,810 ug litre^{-1}) at the Cherry Street bridge (station 1379), 840 ug litre^{-1} (range 820 ug litre^{-1}) near the dredge site (station 2017), and 420 ug litre^{-1} (range 280 ug litre^{-1}) at the central harbour location (station 1364). Median values of 320 ug litre^{-1} and 300 ug litre^{-1} were observed at the open lake control stations (stations 1998, 1997). Concentrations in the vicinity of the East Headland ranged from medians of 590 ug litre^{-1} (range 590 ug litre^{-1}), approximately 500 m north of the lakefilling (station 1999), to 340 ug litre^{-1} (range 120 ug litre^{-1}) at the mouth of endikement cell #2 (station 2018).

3.2.3 Trace Metals

Six trace metals were analyzed for: arsenic, cadmium, chromium, filtered mercury, lead and zinc. With the exception of cadmium, no samples at any station were detected in excess of the PWQO during the four surveys. In general, trace metal data contained too many results less than or near the MRA for the application of tests for station and sampling period effects. Accordingly, comparison of results between stations has been confined to summarized results (Tables 11 to 16) in a manner similar to previous parameters.

Maximum recorded concentrations for total arsenic (Table 11) were 1 ug litre^{-1} (the MRA) or less, for all stations throughout the study area with no apparent increases in receiving water concentrations near potential sources such as the Don River or the Main STP. The same pattern was generally true for total cadmium (Table 12) where concentrations greater than the MRA of 0.2 ug litre^{-1} (which is also the PWQO) were detected only in the lower Don River (station 2020).

Results for total chromium (Table 13) show that generally uniform median concentrations of 2 or 3 ug litre^{-1} occurred, with ranges of 5 ug litre^{-1} or less, at all but four stations. The exceptions were recorded in the lower Don River station (station 2020) with a median concentration of 15 ug litre^{-1} (range 30 ug litre), near the Cherry Street bridge (station 1379) with a median concentration of 6 ug litre^{-1} (range 8 ug litre^{-1}), near the dredge site with a median result of 5 ug litre^{-1} (range 3 ug litre^{-1}), and near the Main STP discharge (station 1419) with a median of 4 ug litre^{-1} (range 6 ug litre^{-1}).

Total filtered mercury also displayed a limited range of median results across the study area (Table 14). The maximum median concentration of 0.04 ug litre^{-1} was detected in the lower Don River (station 2020); the minimum median concentration of 0.01 ug litre^{-1} was recorded at five stations, including near the dredge site (station 2017).

Total lead results (Table 15) indicate the occurrence of uniform median concentrations of less than the MRA (3 ug litre) at 12 of the 16 stations. Only median results from the lower Don River (station 2020) at 6 ug litre^{-1}, the Cherry Street bridge (station 1379) at 5 ug litre^{-1}, the dredge site (station 2017) at 5 ug litre^{-1}, and the disposal cell (station 1984) at 6 ug litre^{-1}, exceeded the MRA of 3 ug litre^{-1}. None of the samples obtained from the vicinity of the Main STP discharge (station 1419) exceeded the MRA.

Median concentrations of total zinc (Table 16) varied from 1 ug litre^{-1} to 3 ug litre^{-1} at 10 of the 16 stations, with ranges of 6 ug litre^{-1} or less. The median result for the lower Don River (station 2020) was 24 ug litre^{-1} (range 15 ug litre^{-1}), diminishing to 12 ug litre^{-1} (range 6 ug litre^{-1}) at the Cherry Street bridge (station 1379), and 8 ug litre^{-1} (range 7 ug litre^{-1}) near the dredge site (station 2017). The maximum median result outside the harbour was measured at the disposal cell (station 1984) with a value of 8 ug litre^{-1} and a range of 11 ug litre^{-1}. A median concentration of 5 ug litre^{-1} (range 6 ug litre^{-1}) was measured near the Main STP discharge (station 1419); a result of 4 ug litre^{-1} was obtained near the lakefilling site (station 1987).

3.2.4 Trace Organics

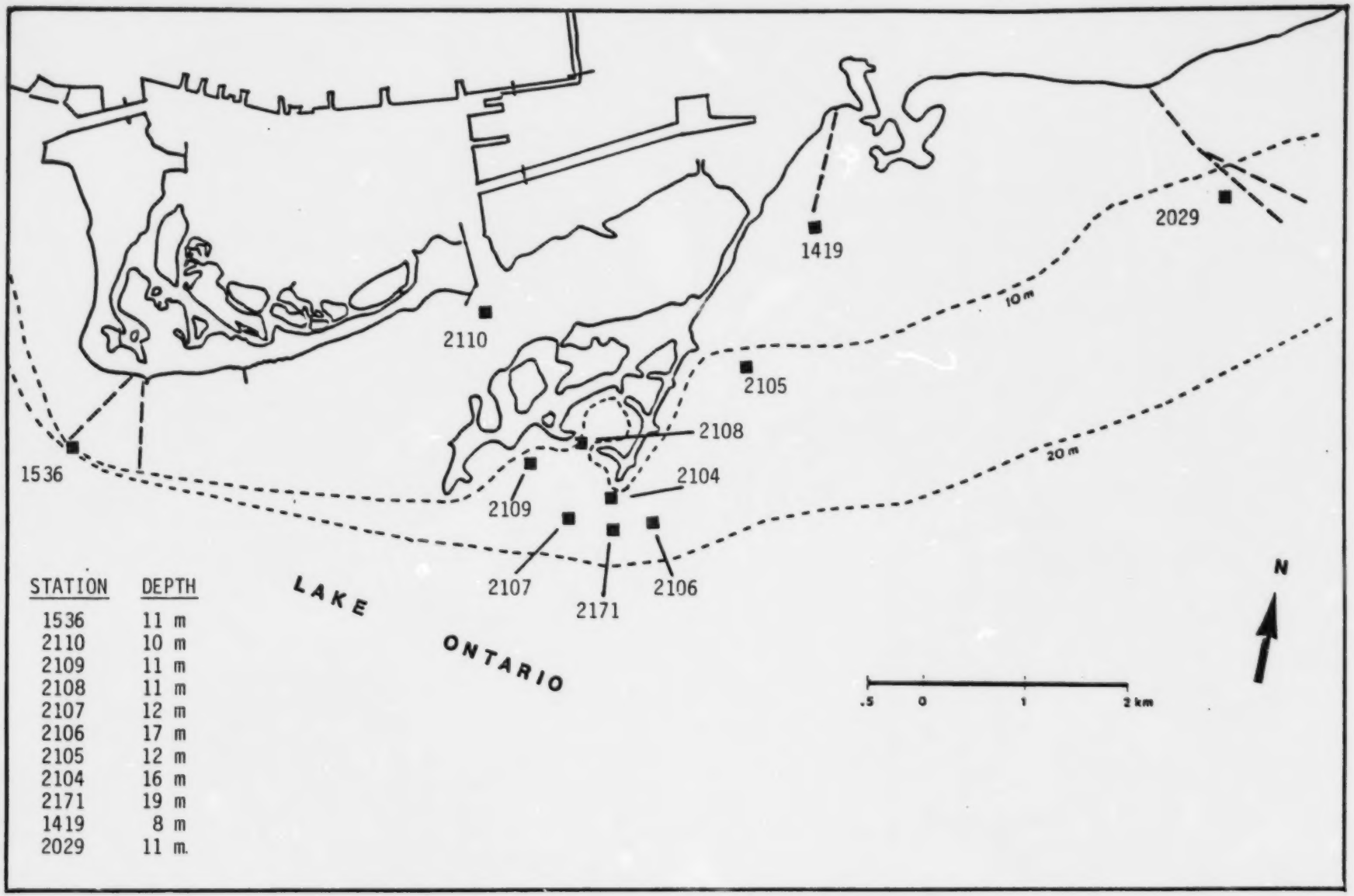
A total of forty-seven organochlorine, organophosphorus, and chlorobenzene compounds were included in the requested organics scan (see Appendix A). Of these, four compounds were detected, at two of the sixteen stations (Table 17). The organochlorine pesticide lindane (gamma BHC) was detected slightly above the PWQO of 10 ng litre^{-1} at both the Cherry Street bridge (station 1379) and near the Main STP discharge (station 1419). The organophosphorus insecticides dichlorvos and mevinphos were each detected in one of four samples near the Main STP discharge (station 1419) at levels of 500 ng litre^{-1} and 140 ng litre^{-1}, respectively. In addition, 1,2,3,4-tetrachlorobenzene was detected at a level of 11 ng litre^{-1} (PWQO 100 ng litre^{-1}) in one of nine samples obtained near the Main STP discharge (station 1419).

3.3 Suspended Particulate Quality

Suspended particulates were sampled at those stations where a sufficient volume of material could be concentrated with a centrifuge during a two to three hour period. These were: the Cherry Street bridge (station 1379), the dredge site (station 2017), the East Headland disposal cell (station 1984), the lakefilling site (station 1987) and the Main STP discharge (station 1419). Results for percentage loss on ignition (% LOI), nutrients, trace metals, PCBs, and organochlorine pesticides have been listed (Tables 18, 19). Results from a previous sediment trap investigation (with traps installed 1 m from the bed) conducted within the study area during 1983 and 1984 have also been presented (Table 20, Figure 4) (Boyd 1986).

3.3.1 Physical Parameters

Only one result of particle size analysis was available for the 1984 centrifuged samples. This showed particle diameters from the sample obtained at the Cherry Street bridge (station 1379) on 11 July 1984, to have ranged from 6.1 phi (14.9 um: fine silt) to 12.0 phi (0.24 um: very fine clay), with a mean of 8.6 phi (2.6 um: coarse clay). This is likely to be representative of material centrifuged from near the surface at other stations, and contrasts with the mean diameters recorded from sediment trap samples obtained 1 m from the bed. These ranged from 4.3 phi (50.8 um: coarse silt) to 7.2 phi (6.8 um: very fine silt) depending upon the season and, to a lesser extent, the location (Boyd 1986).



STATION	DEPTH
1536	11 m
2110	10 m
2109	11 m
2108	11 m
2107	12 m
2106	17 m
2105	12 m
2104	16 m
2171	19 m
1419	8 m
2029	11 m

FIGURE 4 : Sediment Trap Locations 1983/84

Centrifuged particulate results (Table 18) for %LOI indicate a similar range of approximately 10% to 15% for the Cherry Street bridge site (station 1379) and the dredge site (station 2017). Results from stations at the East Headland and Main STP were more variable, ranging from 1.1% to 28.4% at the lakefilling operation (station 1987), from 11.5% to 24.2% at the disposal cell (station 1984), and from 15.2% to 38.6% near the Main STP discharge (station 1419). Material collected near the lakefilling and the Main STP by sediment traps (Table 20) did not exceed 6% LOI.

3.3.2 Nutrients

Total phosphorus results for centrifuged particulates (Table 18) indicate a relatively uniform range of approximately 1 mg g^{-1} to 4 mg g^{-1} at the Cherry Street bridge (station 1379), the dredge site (station 2017), and the disposal cell (station 1984). Results from the lakefilling varied from 0.8 mg g^{-1} to 4.9 mg g^{-1}, while the single sample obtained near the Main STP discharge (station 1419) was recorded to have a concentration of 19.5 mg g^{-1}. Sediment trap results from the vicinity of the Main STP ranged from 1.0 mg g^{-1} to 3.2 mg g^{-1}, with concentrations near the lakefilling from 0.7 mg g^{-1} to 1.2 mg g^{-1} (Table 20).

Total Kjeldahl nitrogen concentrations for centrifuged particulates ranged from 4.5 mg g^{-1} to 6.5 mg g^{-1} at the Cherry Street bridge (station 1379) and dredge site (station 2017), and were slightly more variable at the disposal cell (station 1984) with results from 1.4 mg g^{-1} to 9.0 mg g^{-1}. The lakefilling site was the most variable of all, with concentrations ranging from 0.5 mg g^{-1} to 25.8 mg g^{-1}. A concentration of 24.4 mg g^{-1} was obtained in the only sample from the vicinity of the Main STP discharge (station 1419).

TABLE 18
1984 EFFECTS OF DREDGING/LAKEFILLING
CENTRIFUGED PARTICULATES - Nutrients, Metals, % LOI

Station	Date	TP (mg/g)	TKN (mg/g)	% LOI	Fe (mg/g)	Ag (ug/g)	As (ug/g)	Cd (ug/g)	Cr (ug/g)	Cu (ug/g)	Hg (ug/g)	Ni (ug/g)	Pb (ug/g)	Zn (ug/g)
1379	11/07/84	1.9	-	9.9	-	-	5.44	3.1	110	-	0.26	-	220	390
	24/07/84	2.6	-	10.2	-	-	10.13	2.5	50	100	0.34	-	200	360
	11/10/84	2.6	4.5	12.7	28	4.0	3.77	3.1	130	190	1.00	34	230	450
	28/11/84	3.8	5.0	14.0	30	6.5	4.70	3.2	110	160	0.54	38	200	420
2017	24/07/84	3.4	-	14.6	-	-	5.04	3.7	100	110	0.42	-	240	430
	11/10/84	2.5	6.5	11.0	22	2.1	5.92	2.4	71	110	0.57	25	180	310
	29/11/84	3.0	5.2	14.2	26	5.0	4.35	3.2	90	130	0.52	28	250	410
1984	25/07/84	2.4	-	11.6	-	-	7.19	2.9	170	72	0.28	-	170	270
	12/10/84	2.4	9.0	13.9	29	2.6	11.08	3.3	71	110	0.33	31	250	360
	15/10/84	2.4	7.2	11.5	30	3.2	8.64	3.5	74	120	0.41	31	280	410
	27/11/84	0.9	1.4	24.2	21	2.5	3.84	2.2	61	76	0.29	22	180	260
1987	25/07/84	1.5	-	8.0	-	-	4.74	1.3	55	39	0.18	-	97	170
	23/10/84	3.8	20.1	28.4	18	0.85	10.95	2.2	81	84	0.21	41	93	180
	24/10/84	4.9	25.8	-	17	1.6	10.51	2.5	74	76	0.21	27	81	190
	30/11/84	0.8	0.5	1.1	7.9	0.5	1.28	0.39	21	70	0.05	11	52	66
1419	26/07/84	-	-	38.6	-	-	7.19	-	-	-	-	-	-	-
	20/10/84	19.5	24.4	-	31	33.0	6.76	9.1	430	350	1.00	54	140	500
	01/12/84	-	-	15.2	-	-	-	-	-	-	-	-	-	-

" - " = not sampled.

TABLE 19

1984 EFFECTS OF DREDGING/LAKEFILLING

CENTRIFUGED PARTICULATES - Trace Organics
(results from OC scan, only compounds detected are shown)
All concentrations in ng/g

Station	Date	PCBs	Chlordane	Chlordane	Dieldrin	HCB	ppDDE	ppDDD	Endosulphan 1	Endosulphan SO4
1379	11/07/84	60	10	6	8	ND	ND	ND	ND	ND
	24/07/84	82	3	3	ND	3	ND	ND	ND	ND
	28/11/84	2610	ND	ND	15	659	371	ND	ND	46
2017	24/07/84	80	9	9	ND	2	ND	5	ND	ND
	29/11/84	520	ND	ND	ND	41	16	ND	30	ND
1984	25/07/84	125	5	7	ND	2	2	12	ND	ND
	27/11/84	380	ND	ND	ND	8	15	ND	ND	ND
1987	25/07/84	21	6	6	ND	1	3	4	ND	ND
	30/11/84	90	ND	ND	4	5	19	ND	ND	ND
1419	26/07/84	25	ND	ND	ND	7	ND	ND	ND	ND
	01/12/84	ND	ND	ND	4	22	13	ND	ND	ND

ND = not detected

TABLE 20

SELECTED CHEMISTRY RESULTS FROM TORONTO WATERFRONT SEDIMENT TRAP SAMPLES

STATION LOCATIONS

Parameter	Retrieval*	1536	1419	2029	2104/71	2105	2106	2107	2108	2109	2110
%LOI	1	5.7	5.7	11.0	1.1	9.0	8.8	-	3.3	-	7.8
	2	4.5	3.5	7.1	-	3.5	6.2	-	4.4	4.4	5.9
	3	5.6	3.5	8.0	3.8	4.8	6.0	4.4	-	-	6.5
	3a	-	-	-	-	-	-	-	2.2	2.6	-
	4	5.1	1.6	3.2	2.3	-	-	3.0	-	5.2	-
Total P (mg/g)	1	1.1	3.2	1.30	0.80	1.3	1.2	0.9	0.8	0.6	1.4
	2	1.3	1.5	1.30	-	1.1	1.0	-	1.1	1.1	1.3
	3	1.5	1.2	1.30	1.20	1.2	1.3	1.5	-	-	1.3
	3a	-	-	-	-	-	-	-	1.0	1.1	-
	4	1.1	1.0	0.90	0.70	-	-	0.9	-	0.9	-
As (ug/g)	1	11.23	3.08	7.36	3.01	13.11	8.10	4.61	4.79	3.22	12.80
	2	5.31	3.64	5.64	-	3.95	5.43	-	6.39	5.64	6.50
	3	6.39	3.53	5.75	4.16	5.54	6.39	5.11	-	-	5.64
	3a	-	-	-	-	-	-	-	4.58	3.74	-
	4	6.35	3.03	4.48	3.21	-	-	4.12	-	5.46	-
Cd (ug/g)	1	1.6	2.80	2.10	0.53	2.90	1.60	-	0.82	-	1.80
	2	1.7	1.10	1.30	-	0.59	1.20	-	0.80	1.20	1.60
	3	1.8	0.60	1.02	0.63	0.73	0.70	0.78	-	-	2.02
	3a	-	-	-	-	-	-	-	0.72	0.77	-
	4	1.8	0.73	0.75	0.70	-	-	1.10	-	1.20	-
Hg (ug/g)	1	0.38	0.73	0.61	0.11	0.37	-	0.32	0.18	-	0.40
	2	0.30	0.17	0.18	-	0.13	0.15	-	0.23	0.19	0.30
	3	0.24	0.11	0.12	0.15	0.16	0.14	0.23	-	-	0.35
	3a	-	-	-	-	-	-	-	0.16	0.14	-
	4	0.14	0.05	0.07	0.08	-	-	0.12	-	0.19	-
Pb (ug/g)	1	85.0	94.0	80.0	92.0	99.0	74.0	-	53.0	-	110.0
	2	77.0	36.0	44.0	-	26.0	44.0	-	93.0	87.0	93.0
	3	73.7	31.0	47.2	53.5	37.5	42.5	61.0	-	-	131.5
	3a	-	-	-	-	-	-	-	58.0	59.0	-
	4	45.0	17.0	20.0	37.0	-	-	44.0	-	58.0	-
Zn (ug/g)	1	240	230	220	100	220	160	-	89	-	210
	2	160	110	150	-	92	130	-	140	140	170
	3	169	87	136	106	112	128	120	-	-	229
	3a	-	-	-	-	-	-	-	100	94	-
	4	110	48	58	58	-	-	87	-	100	-

* Retrieval: 1 (July 1983), 2 (Aug. 1983), 3 (Oct/Nov. 1983), 3a (Dec. 1983), 4 (May/June 1984)

NOTE: Stations 2104 and 2171 are equivalent to water quality station 1987.

3.3.3 Trace Metals

Centrifuged suspended particulate results for iron, silver, arsenic, cadmium, chromium, copper, mercury, nickel, lead and zinc have been listed (Table 18), along with suspended particulates results from sediment traps for arsenic, cadmium, mercury, lead and zinc (Table 20).

Centrifuged particulate results indicate maximum concentrations near the Main STP discharge (station 1419) for silver (33.0 ug g^{-1}), cadmium (9.1 ug g^{-1}), chromium (430 ug g^{-1}), copper (350 ug g^{-1}), nickel (54 ug^{-1}) and zinc (500 ug g^{-1}). Maximum results for iron (31 mg g^{-1}) and mercury (1.00 ug g^{-1}) at this station were similar to those obtained at the Cherry Street bridge (station 1379) for mercury, and the bridge, the dredge site (station 2017), and the disposal cell (station 1984) for iron.

Lead results were distinctive in that maximum concentrations occurred at the Inner Harbour stations (stations 1379, 2017) and the disposal cell (station 1984), where observations ranged from 170 ug g^{-1} to 280 ug g^{-1}. This range exceeded the observation from the vicinity of the Main STP discharge (station 1419) of 140 ug g^{-1}.

Arsenic concentrations tended to be variable at the Cherry Street bridge (station 1379), the disposal cell (station 1984), and the lakefilling site (station 1987), with results ranging from approximately 1 ug g^{-1} to 12 ug g^{-1}, so that no readily observable ranks were evident between stations.

The tendency for maximum concentrations of most metals to be observed near the Main STP discharge (station 1419) was contrasted by the tendency for the lowest concentrations to be recorded near the lakefilling site (station 1987). Maximum results (Table 18) for iron, silver, cadmium, chromium, copper, mercury, lead, and zinc at the lakefilling station were all below the range of concentrations for these parameters observed at other stations.

Sediment trap results for trace metals (Table 20) show that the most significant degree of variation occurred between sampling periods rather than between stations, so that stations could not be characterized through comparison of single parameters (Boyd 1986).

Arsenic results for sediment traps near the Main STP discharge (station 1419) and lakefilling (station 2104/71) indicate a range of approximately 3 ug g^{-1} to 4 ug g^{-1} at both stations, compared with centrifuge results of approximately 6 ug g^{-1} to 7 ug g^{-1} at the Main STP discharge, and 1 ug g^{-1} to 11 ug g^{-1} at the lakefilling.

Sediment trap results for cadmium ranged from 0.6 ug g^{-1} to 2.8 ug g^{-1} near the Main STP discharge, and from 0.53 ug g^{-1} to 0.70 ug g^{-1} at the lakefilling. Corresponding results for centrifuged samples were 9.2 ug g^{-1} for the single sample available at the Main STP discharge, and from 0.39 ug g^{-1} to 2.5 ug g^{-1} at the lakefilling site.

Mercury concentrations near the Main STP varied from 0.05 ug g^{-1} to 0.73 ug g^{-1} for sediment trap particulates compared with the single centrifuge sample result of 1.00 ug g^{-1}. At the lakefilling site, mercury concentrations for both sediment trap and centrifuge samples fell within the range 0.05 ug g^{-1} to 0.21 ug g^{-1}.

Near the lakefilling, sediment trap lead concentrations ranged from 37 ug g^{-1} to 92 ug g^{-1}, while zinc varied from 58 ug g^{-1} to 106 ug g^{-1}. A similar range for lead (52 ug g^{-1} to 97 ug g^{-1}) was found in centrifuged samples at this location, but a greater range of zinc concentrations was recorded (66 ug g^{-1} to 190 ug g^{-1}). At the Main STP discharge, sediment trap sample lead concentrations varied from 17 ug g^{-1} to 94 ug g^{-1}, with zinc results of from 48 ug g^{-1} to 230 ug g^{-1}. In centrifuge samples from this station single values of 140 ug g^{-1} for lead, and 500 ug g^{-1} for zinc were obtained.

3.3.4 Trace Organics

Centrifuged suspended particulate data for PCBs and organochlorine compounds have been listed (Table 19) for the nine parameters which were detected out of the 22 parameter scan (see Appendix B).

Total PCBs and HCB were detected at least once at each of the five centrifuge stations with the respective maximum concentrations of 2,610 ng g^{-1} and 659 ng g^{-1} being recorded at the Cherry Street bridge (station 1379).

Alpha chlordane was detected in one or more samples at all locations except near the Main STP discharge (station 1419). Results ranged from 3 ng g^{-1} to 10 ng g^{-1} with the maximum concentration observed at the Cherry Street bridge (station 1379). The pattern of detection for gamma chlordane was identical to alpha chlordane, with results ranging from 3 ng g^{-1} to a maximum of 9 ng g^{-1} at the dredge site (station 2017).

Dieldrin was detected at the Cherry Street bridge (station 1379), the lakefill site (station 1987) and near the Main STP discharge (station 1419) at levels ranging from 4 ng g^{-1} to a maximum of 15 ng g^{-1} at the Cherry Street bridge.

The DDT metabolite, p,p-DDE was also measurable in one or more samples at all five stations. Once again, the maximum concentration (371 ng g^{-1}) was recorded at the Cherry Street bridge. Another metabolite, p,p-DDD, was detected at three stations (the dredge site, the disposal cell, and the lakefilling) with the maximum concentration (12 ng g^{-1}) being recorded at the disposal cell (station 1984).

Endosulphan 1 was detected in only one sample near the dredge site (station 2017) at a concentration of 30 ng g^{-1}. Endosulphan sulphate was also detected only once, at a concentration of 46 ng g^{-1}, at the Cherry Street bridge.

4.0 DISCUSSION

4.1 Turbidity Profiling

Turbidity and temperature profiling results for the Inner Harbour (Table 5) confirmed previous findings that turbidity plumes from the Don River obscured effects of dredging, except in the immediate vicinity of the dredge. Results also demonstrated the sensitivity of plume behaviour to thermal conditions in the relatively sheltered Inner Harbour environment. These observations indicate that surface water quality in the harbour, particularly the northeast corner, will reflect the influence of flow from the Don River to a greater extent during the summer, when the river water temperature greatly exceeds that of the receiving water, than later in the season when this temperature difference has decreased.

Profiling results from the vicinity of the lakefilling (Table 6) showed less direct response to thermal conditions, probably as a result of the exposure to open lake waves and currents. Under stormy conditions, previous findings were confirmed since wave action tended to hold particulates in suspension near the lakefilling. Such conditions, however, also tended to complicate interpretation of plume extent due to interference from erosion and resuspension along the older, inactive portion of the lakefill project.

The observed tendency for plumes to sink and disperse downrange from the lakefilling suggests that surface water quality sampling cannot be expected to characterize the maximum effect of lakefilling on receiving water quality.

4.2 Water Quality

A high degree of interaction between station effects and sampling period effects (see Appendix E) for conductivity, turbidity, and nutrients was observed. This reflects the effect of variable point source discharges on both water quality variability between sampling locations during one survey, and between sampling periods at one location. Differences in point source discharges between sampling periods can be expected as the result of such factors as changes in flows from rivers and STPs during precipitation events, or changes in erosional inputs from lakefilling during storms. Such temporal variability cannot be independent from spatial variability wherever proximity to source is the fundamental cause for among-station differences observed in water quality throughout the nearshore zone. Since it is unlikely that all point-source discharges within the study area will vary identically, relative differences between stations can be expected to change from one sampling period to the next.

Another consequence of the effects of both location and sampling period on water quality is the apparent dependence between means and variances. The largest means for various water quality parameters are found in the immediate vicinity of point source discharges. Since the magnitude of variability between sampling periods must necessarily be greater near a discharge than removed from it, variances incorporating results from different sampling periods will also tend to be greater.

The design of future water quality surveys in the Toronto nearshore zone should acknowledge the evidence that water chemistry parameters will reflect the interaction between sampling location and sampling period. In many cases ambient conditions will be more usefully described by medians and ranges than means and variances, and nonparametric tests of significance for spatial or temporal effects may be the most appropriate method of avoiding application of data transformation. Comparison of station effects alone, however, may not be a meaningful means of reaching conclusions about typical conditions.

4.2.1 Physical Parameters

Results for the physical parameters conductivity 25°C and turbidity Tables 7 and 8) are of interest in that conductivity measurements provide an excellent indication of dissolved solids content, whereas turbidity also reflects the influence of suspended particulates. Given this difference, the extreme turbidity values recorded at the dredging, disposal, and lakefilling stations which were not accompanied by corresponding conductivity peaks, suggest that any observed increases in concentrations of other parameters at these stations were likely to be associated with particulates rather than dissolved load. On the other hand, water quality results from the lower Don River and the vicinity of the Main STP discharge were more likely to reflect a combination of particulate and dissolved loads.

4.2.2 Nutrients

Total phosphorus (TP) measurements (Table 9) include various phosphorus compounds, such as organically bound phosphates, which would not be released to any great extent in the filtered total phosphorus procedure (Ontario Ministry of the Environment 1983). Phosphorus compounds are commonly found in waste water and runoff.

The pattern of concentrations above the Provincial guideline (20 ug litre^{-1}) in the northeast corner of the Inner Harbour and the vicinity of the Main STP discharge suggests that flows from the Don River and the Main STP were the primary sources of phosphorus to the waterfront area east of Humber Bay, although disposal and lakefilling operations at the East Headland did result in some localized increases. It is also evident that even background concentrations throughout the Toronto nearshore zone do not meet the 20 ug litre^{-1} Provincial guideline (for avoidance of nuisance concentrations of algae) all the time. Other factors, such as lack of suitable substrate, appear to be responsible for the general lack of algae related impairment of water use throughout the study area.

Total Kjeldahl nitrogen (TKN) (Table 10) is primarily a measure of nitrogen present in the organic form, soluble or particulate, as well as nitrogen present as free ammonia (Ontario Ministry of the Environment 1983).

The extreme concentrations found in the lower Don River and near the Main STP discharge are not unexpected, given that STP effluent and runoff from areas where fertilizers have been used are primary sources of TKN. Results obtained near dredging and lakefilling activities provide no indication of significant contributions from these sources.

4.2.3 Trace Metals

Water quality results for trace metals (Tables 11 to 16) demonstrated the general tendency for concentrations of most metals to meet the respective PWQO for the protection of aquatic life and recreation. Only cadmium (Table 12) was detected above the 0.2 ug litre $^{-1}$ PWQO, in four of nine samples obtained in the lower Don River with concentrations ranging from 0.3 ug litre^{-1} to 0.6 ug litre^{-1}.

With the exception of arsenic (which showed no variation across the study area), all trace metals (i.e. cadmium, chromium, filtered mercury, lead and zinc) displayed maximum concentrations in the lower Don River and the northeast corner of the Inner Harbour. Results obtained near the dredging operation provided no apparent evidence of localized increases, although the concentration gradient from the river to background conditions in the harbour would be expected to have obscured any relatively minor increases. Results for other stations showed slight elevations above background concentrations for zinc (Table 16) and chromium (Table 13) near the Main STP discharge, and for zinc near the lakefilling. At the disposal cell, concentrations of lead (Table 15) and zinc (Table 16) were distinctly elevated in comparison with background observations. Since turbidity levels were also elevated at this location, it is reasonable to conclude that high concentrations of suspended particulates with adsorbed metals were responsible.

4.2.4 Trace Organics

The infrequent detection of organic compounds in water samples could not be attributed to either dredging or lakefilling activities. Results did indicate that both the Don River and receiving water near the Main STP discharge contained the insecticide lindane (Table 17) at concentrations slightly greater than the PWQO of 10 ng litre^{-1} (i.e 15 ng litre^{-1} at the Main STP, 16 ng litre^{-1} at the Don River). This implies that lindane is entering both the Don watershed and the trunk sewer system and demonstrates that the general decline in large scale agricultural application (McGee 1984) cannot be used to make predictions about loading trends in urban settings.

4.3 Suspended Particulate Quality

Collection of suspended particulates, by means of a centrifuge or with sediment traps, provides a means of concentrating material and adsorbed contaminants from the water column. In many cases these contaminants cannot be detected in water samples at current detection limits (i.e. ng litre^{-1} or parts per trillion) because the concentration of particulates in the water column is not sufficiently great. Once the particulates have been concentrated into a sediment rather than a water sample, the presence of relatively hydrophobic trace metals and organic compounds can be detected.

Although samples are submitted (and chemistry results reported) as sediment samples, they are not bed sediments and, consequently, comparison with MOE dredging guidelines for open water disposal (Persaud and Wilkins 1976) is not meaningful.

4.3.1 Physical Parameters

The only available particle size analysis for centrifuged particulates showed the material to have been considerably finer than that collected in sediment traps 1 m from the bed. This finding is to be expected since centrifuged samples were obtained near the surface where only extremely fine particles (or low density material) are held in suspension. In general, results for % LOI also reflected the difference between sampling near the bed and near the surface. Although variable, % LOI in surface centrifuged samples generally exceeded results from sediment traps by a substantial margin. This can be attributed to a higher content of lo w density organic material.

4.3.2 Nutrients

The range of concentrations for total phosphorus from centrifuged particulate samples exceeded that from sediment trap samples. Since analysis for this parameter includes organically bound phosphates, the greater concentrations of organic material recovered in centrifuged samples may have been partially responsible for this finding (although linear correlations between % LOI and total phosphorus in both sediment trap and centrifuged samples were not significant).

The high degree of variability observed in total Kjeldahl nitrogen results for centrifuged particulates from the vicinity of the East Headland contrasts with the more uniform pattern observed in the northeast corner of the Inner Harbour. These observations are to be expected since inputs from lakefilling will tend to be intrinsically variable (i.e. they will reflect variable soil conditions from various excavation sites), and since mixing will depend upon a variable range of physical conditions in the receiving water near the lakefilling.

4.3.3 Trace Metals

In general, maximum concentrations of most trace metals (Ag, Cd, Cr, Cu, Ni, Zn) in centrifuged samples were recorded near the Main STP discharge, whereas minimum concentrations were observed near the lakefilling. Although the data are not adequate to quantify the significance of this difference, the diverse range of inputs (i.e. industrial, sanitary, and stormwater) to the Main STP may be expected to provide a greater average potential for elevated concentrations of metals associated with particulates discharged as final effluent than suspended particulates derived from lakefill material. Results from sediment traps near the lakefilling and Main STP discharge did not illustrate an equivalent difference between suspended particulates collected 1 m from the lake bed. The mixing and sorting of particulates according to size and density which would have accompanied settling, may have been responsible for the more homogeneous chemistry results obtained between sediment traps located 1 m from the bed.

For similar station locations, the ranges of concentrations for certain trace metals were higher in centrifuged samples than trap samples and, as with previously described parameters, differences in the relative percentages of organic and fine-grained material were most likely to have caused this. This explanation can be extended to account for the finding that the range of concentrations of metals (and nutrients) was generally lower in bed sediments sampled in 1982 (Persaud *et al.* 1985) than centrifuged or trap samples. This difference can be reduced if a grain size correction is applied to compensate for the percentage of sand present in many of the bed samples, which were absent from trap and centrifuged samples. Application of such a correction is appropriate in this case, since significant positive correlations ($r^2 > 0.40$ at $p < 0.05$) exist between percentage silt/clay and concentrations of copper, lead, and zinc in the 1982 bed sediment samples.

These findings indicate the need for further investigation into sediment transport and seasonal variability in Toronto waterfront depositional environments since it is evident that much of the fine-grained or organic material comprising suspended particulates is either not deposited, or is rapidly resuspended and transported away from the point at which it entered the lake.

4.3.4 Trace Organics

The list of organochlorine compounds detected in 1984 centrifuged particulate samples increased slightly from results obtained in the vicinity of the East Headland in 1982 (Boyd and Griffiths 1985). Dieldrin, HCB, p,p-DDE, p,p-DDD, endosulphan I, and endosulphan sulphate, were all detected for the first time in Toronto waterfront centrifuged samples.

Although the limited sampling frequency necessitates caution in the interpretation of results, it is evident that concentration of particulates with the centrifuge and analysis as a sediment sample enabled the detection of a greater range of organic compounds than water quality analysis near potential sources such as the Don River, the dredging and disposal operations, the lakefilling site, and the Main STP discharge. Results confirmed the presence of suspended particulates with adsorbed organics (and trace metals) at all these locations. This clearly demonstrates that the failure to detect these compounds in the aqueous phase cannot preclude their potential for indirect effects on the aquatic environment.

Preliminary findings from a sediment trap survey in 1983 and 1984 (Boyd 1986) indicated that relative fluxes of suspended particulates 1 m from the bed near the Main STP discharge, and the lakefilling site were approximately the same, and were an order of magnitude greater than those measured near the Toronto Island and R.C. Harris filtration plant intakes. This suggests that particulates being transported away from these sources are creating localized zones of near-bed contaminant fluxes significantly greater than at background stations. However, these data do not permit computation of actual loadings.

5.0 SUMMARY OF FINDINGS

Major findings of the study were as follows:

(1) Effects of dredging and lakefilling activities on concentrations of nutrients and metals are localized and generally secondary to effects of flows from the Don River and the Main STP.

(2) The behaviour of the turbidity plume from the Don River, which generally masked effects from dredging activity, depends upon thermal conditions in the Inner Harbour. On one occasion it was tracked across the eastern side of the harbour to the Eastern Gap.

(3) Turbidity plumes originating from the lakefilling activity tend to sink and disperse to background levels within 0.5 - 1.0 km, although stormy conditions may maintain a surface plume in the immediate vicinity of the lakefilling.

(4) Physical parameters and nutrients demonstrate a high degree of interaction between sampling location and sampling period effects. This means that no generalized description of differences between stations can be made on the basis of a single survey, nor can differences between sampling periods be generally assessed using results at only a single station.

(5) Nutrient concentrations are greatest near the Main STP discharge and in the lower Don River. These same stations exhibit the greatest dissolved solids concentrations.

(6) Total phosphorus results indicate that at some time during the survey season virtually all stations within the study area exceed the Provincial guideline of 20 ug litre^{-1}. However, algae related impacts on water use do not appear to be a general problem through the nearshore zone.

(7) The greatest concentrations of trace metals are found in the lower Don River, although localized elevations above background levels are detected for lead and zinc near the headland, and near the Main STP for zinc and chromium. Of the trace metals, only cadmium was detected above the Provincial Water Quality Objective (PWQO) of 0.2 ug litre^{-1}, and this occurred only in the lower Don River.

(8) Trace organic compounds can be detected in water samples at the mouth of the Don River (gamma-BHC in 4 of 12 samples), and near the Main STP discharge (1,2,3,4-tetrachlorobenzene in 1 of 9 samples, dichlorvos in 1 of 4 samples, mevinphos in 1 of 4 samples, and gamma-BHC in 2 of 12 samples). Gamma-BHC (lindane) concentrations may exceed the PWQO of 10 ng litre^{-1} at both locations.

(9) Trace metals can be detected in centrifuged particulate samples obtained at the mouth of the Don River, the dredging and disposal sites, the lakefilling site and the Main STP discharge. Maximum concentrations tend to be detected in material centrifuged near the Main STP (except for arsenic and lead) with minimum concentrations in samples from near the lakefilling (except for arsenic).

(10) Trace organic compounds can be detected in centrifuged particulates. A total of nine organochlorine compounds were detected in centrifuged particulate samples with PCBs, HCB and p,p-DDE being detected in one or more samples at all centrifuge stations. Seven of these compounds (PCB, alpha-chlordane, gamma-chlordane, dieldrin, HCB, p,p-DDE, and p,p-DDD) were detected in samples obtained near the lakefilling activity.

(11) Comparison of centrifuged particulate samples taken near the surface with particulates collected in traps near the bed shows a general tendency for the surface material to be finer with a higher content of organic material and slightly greater concentrations of nutrients and metals. Textural and organic content differences may also account for much of the increase in concentrations of contaminants found in suspended particulates when compared with bed sediments at corresponding locations throughout the study area.

6.0 RECOMMENDATIONS

Results from the 1984 study have identified the need for future investigation into sediment transport, chemical characterization of inputs, and biomonitoring in order to address emerging concerns and to complement work currently in progress as part of the Ministry's "Inplace Pollutants" programme. These concerns and associated recommendations have been listed below.

(1) Concern:

Hydrophobic trace metals and organics associated with suspended particulates may have an adverse impact on aquatic biota through direct exposure in the water column.

Recommendation:

Appropriate test organisms should be used to identify bioavailable hydrophobic compounds associated with suspended particulates in the zone between their point of discharge and deposition.

(2) Concern:

Hydrophobic trace metals and organics associated with suspended particulates may be responsible for long-term, indirect impacts on the aquatic ecosystem (following transport and deposition) due to uptake and accumulation via benthic organisms.

Recommendation:

A comprehensive investigation into the transport and deposition of suspended particulates from Toronto waterfront sources should be initiated to identify those areas (and seasons) where (and when) bed sediment quality is degraded through deposition of contaminated particulates.

Recommendation:

Physical and chemical assessment of suspended particulates from Toronto waterfront sources should be pursued both through direct sampling within the effluent stream or river, and through collection in the receiving water. This will allow assessment of the relative significance of contaminant fluxes from various sources, and may identify distinctive chemical associations capable of linking sources with receiving environment findings.

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APPENDIX A: 1984 TORONTO WATERFRONT WATER QUALITY TESTS

Physical Parameters, Nutrients, and Trace Metals

Conductivity 25°
US/CM at 25°C

Turbidity FTU

Phosphorus, UNF, Total
mg/L as P

Nitr'n Total Kjeld, UNF, R
mg/L as N

Arsenic, UNF, Total
mg/L as As

Cadmium, UNF, Total
mg/L as Cd

Chromium, UNF, Total
mg/L as Cr

Mercury, FILT, Total
ug/L as Hg

Lead, UNF, Total
mg/L as Pb

Zinc, UNF, Total
mg/L as Zn

Organochlorine, Organophosphorus, and Chlorobenzene Compounds

Pentachlorobenzene ng/L

PCB, Total ng/L

Hexachlorobenzene ng/L

Heptachlor ng/L

Aldrin ng/L

PP-DDE ng/L

Mirex ng/L

A-BHC (Hexachlorocyclohexane)
ng/L

G-BHC (Hexachlorocyclohexane)
ng/L

A-Chlordane ng/L

G-Chlordane ng/L

Oxychlordane ng/L

OP-DDT ng/L

PP-DDE ng/L

DMDT (Methoxychlor) ng/L

Heptachlorepoxide ng/L

Endosulfan I ng/L

Dieldrin ng/L

Endrin ng/L

Endosulfan II ng/L

Endosulfan Sulphate
ng/L

Octachorostyrene ng/L

B-BHC (Hexachlorocyclohexane)
ng/L

Hexachloroethane ng/L

1,3,5-Trichlorobenzene ng/L

1,2,4-Tichlorobenzene ng/L

Hexachlorobutadiene ng/L

1,2,3-Trichlorobenzene ng/L

2,4,5-Trichlorotoluene ng/L

2,3,6-Trichlorotoluene ng/L

Appendix A: Organochlorine, Organophosphorus, and Chlorobenzene Compounds (Cont'd)

1,2,3,5-Tetrachlorobenzene ng/L

1,2,4,5-Tetrachlorobenzene ng/L

2,6a-Trichlorotoluene ng/L

1,2,3,4-Tetrachlorobenzene ng/L

Diazinon ng/L

Dichlorovos ng/L

Dursban ng/L

Ethion ng/L

Guthion ng/L

Malathion ng/L

Mevinphos ng/L

Methylparathion ng/L

Methyltrithion ng/L

Parathion ng/L

Phorate (Thimet) ng/L

Reldan ng/L

Ronnel ng/L

APPENDIX B: 1984 TORONTO WATERFRONT SUSPENDED PARTICULATE QUALITY TESTS

Physical Parameters, Nutrients, and Trace Metals

Resid. Total, % Loss on IGN
Percent

Phosphorus, UNF. Total
mg/g dry

Arsenic, UNF. Total
ug/g dry

Cadmium, UNF. Total
ug/g dry

Chromium, UNF. Total
ug/g dry

Copper, UNF. Total
ug/g dry

Mercury, UNF. Total
ug/g dry

Nickel, UNF. Total
ug/g dry

Lead, UNF. Total
ug/g dry

Zinc, UNF. Total
ug/g dry

Organochlorine Compounds

PCB, Total ng/g dry

Hexachlorobenzene, ng/g dry

Heptachlor, ng/g dry

Aldrin, ng/g dry

PP-DDE, ng/g dry

Mirex, ng/g dry

A-BHC (Hexachlorocyclohexane)
ng/g dry

B-BHC (Hexachlorocyclohexane)
ng/g dry

G-BHC (Hexachlorocyclohexane)
ng/g dry

A-Clordane, ng/g dry

G-Chlordane, ng/dry

Oxychlordane, ng/g dry

OP-DDT, ng/g dry

PP-DDD, ng/g dry

PP-DDT, ng/g dry

DMDT (Methoxyclor), ng/g dry

Heptachlorepoxide, ng/g dry

Endosulfan I, ng/g dry

Dieldrin, ng/g dry

Endrin, ng/g dry

Endosulfan II, ng/g dry

Endosulfan Sulphate, ng/g dry

APPENDIX C: RESULTS OF ANALYSIS -- WATER QUALITY

B.O.W./ SITE: LAKE ONTARIO
SAMPLE POINT: TORONTO INNER HARBOUR
STATION ID: 000006-00-01-1364

SAMPLE DATE YYMMDD	HOUR LMT	STN DIST MTRS	SAMP NO.	ASUT ARSENIC UNF.TOT. MG/L AS AS	CDUT CADMIUM UNF.TOT. MG/L AS CD	CRUT CHROMIUM UNF.TOT. MG/L AS CR	U T M: HGUT MERCURY F.TOT. UG/L AS HG	PBUT LEAD UNF.TOT. MG/L AS PB	ZNUT ZINC UNF.TOT. MG/L AS ZN	COND25 CONDUCT. 25C UMHO/CM AT 25 C	NHTKUR K'DAHL N TOTAL FIL.TOT. MG/L AS N	PPUT PHOSPHOR UNF.TOT. MG/L AS P	TURB TURB'ITY FTU
840711	1112		60306				0.03						
			60304				0.02						
			60305				0.05						
840724	1056		60413	0.001	0.0003<	0.002	0.01<	0.003<	0.002	342.0	0.420	0.022	5.80
			60414	0.001	0.0003<	0.002	0.01<	0.003<	0.002	343.0	0.400	0.029	3.50
			60415	0.001	0.0003<	0.002	0.01<	0.003<	0.003	342.0	0.430	0.029	2.80
841011	1230		50706	0.001<	0.0002<	0.002	0.03	0.003<	0.002	350.0	0.400	0.016	1.19
			50707	0.001<	0.0002<	0.003	0.03	0.003<	0.002	350.0	0.360	0.012	1.35
			50708	0.001<	0.0002<	0.001	0.03	0.003<	0.002	295.0	0.390	0.013	1.33
841128	0845		67036	0.001<	0.0002<	0.003	0.02	0.003<	0.004	375.0	0.530	0.046	3.30
			67037	0.001<	0.0002<	0.003	0.02	0.003<	0.004	372.0	0.640	0.050	2.50
			67038	0.001<	0.0002<	0.003	0.02	0.003<	0.006	370.0	0.630	0.053	3.10

B.O.W./ SITE: LAKE ONTARIO
SAMPLE POINT: TORONTO INNER HARBOUR
STATION ID: 000006-00-01-1379

SAMPLE DATE YYMMDD	HOUR LMT	STN DIST MTRS	SAMP NO.	ASUT ARSENIC UNF.TOT. MG/L AS AS	CDUT CADMIUM UNF.TOT. MG/L AS CD	CRUT CHROMIUM UNF.TOT. MG/L AS CR	U T M: HGUT MERCURY F.TOT. UG/L AS HG	PBUT LEAD UNF.TOT. MG/L AS PB	ZNUT ZINC UNF.TOT. MG/L AS ZN	COND25 CONDUCT. 25C UMHO/CM AT 25 C	NHTKUR K'DAHL N TOTAL FIL.TOT. MG/L AS N	PPUT PHOSPHOR UNF.TOT. MG/L AS P	TURB TURB'ITY FTU
840711	1037		60301				0.01						
			60302				0.01						
			60303				0.02						
840724	1032		60410	0.001	0.0003<	0.006	0.03	0.006	0.012	444.0	1.080	0.083	13.60
			60411	0.001	0.0003<	0.007	0.01<	0.007	0.012	448.0	0.790	0.063	12.90
			60412	0.001	0.0003<	0.005	0.01<	0.005	0.008	436.0	0.750	0.056	10.50
841011	1100		50700	0.001<	0.0002<	0.011	0.02	0.006	0.013	477.0	2.450	0.090	14.10
			50701	0.001<	0.0002<	0.010	0.02	0.004	0.011	565.0	2.400	0.093	11.30
			50702	0.001<	0.0002<	0.010	0.01	0.005	0.012	570.0	2.400	0.090	12.70
841128	0910		67039	0.001<	0.0002<	0.004	0.03	0.004	0.008	405.0	0.730	0.079	9.40
			67040	0.001<	0.0002<	0.003	0.02	0.004	0.007	405.0	0.640	0.076	8.40
			67041	0.001<	0.0002<	0.004	0.03	0.004	0.008	405.0	0.780	0.077	9.20

B.O.W./ SITE: LAKE ONTARIO
SAMPLE POINT: TORONTO HARBOUR
STATION ID: 000006-00-01-1419

LAT: 43 38 55.00 LONG: 079 18 51.00 U T M: 17 0635960.2 4834011.1 9 REGION: 01

SAMPLE DATE YYMMDD	HOUR LMT	STN DIST MTRS	SAMP NO.	ASUT ARSENIC UNF.TOT. MG/L AS AS	CDUT CADMIUM UNF.TOT. MG/L AS CD	CRUT CHROMIUM UNF.TOT. MG/L AS CR	HGUT MERCURY F.TOT. UG/L AS HG	PBUT LEAD UNF.TOT. MG/L AS PB	ZNUT ZINC UNF.TOT. MG/L AS ZN	COND25 CONDUCT. 25C UMHO/CM AT 25 C	NHTKUR K'DAHL N TOTAL FIL.TOT. MG/L AS N	PPUT PHOSPHOR UNF.TOT. MG/L AS P	TURB TURB'ITY FTU
840712	1342		60328	0.001<	0.0002<	0.001	0.01<	0.003<	0.005	406.0	2.750	0.080	8.20
			60329	0.001<	0.0002<	0.004	0.01<	0.003<	0.006	409.0	2.800	0.086	5.80
			60330	0.001<	0.0002<	0.001	0.01<	0.003<	0.005	408.0	2.750	0.080	8.30
840725	1541		60476	0.001	0.0002<	0.004	0.01	0.003<	0.004	483.0	6.900	0.148	5.60
			60478	0.001	0.0002<	0.004	0.01<	0.003<	0.004	484.0	7.500	0.139	3.50
			60480	0.001	0.0002<	0.003	0.01<	0.003<	0.004	486.0	6.000	0.132	4.10
841016	1052		50720	0.001<	0.0002<	0.004	0.04	0.003<	0.003	362.0	1.520	0.058	8.80
	1053		50718	0.001<	0.0002<	0.005	0.04	0.003<	0.004	361.0	1.600	0.059	11.50
			50719	0.001<	0.0002<	0.004	0.04	0.003<	0.004	405.0	2.900	0.111	9.90
841127	1054		67006	0.001	0.0002	0.009	0.06	0.003<	0.009	450.0	4.900	0.190	3.90
			67007	0.001	0.0002<	0.008	0.04	0.003<	0.008	405.0	6.900	0.320	2.20
			67008	0.001	0.0002	0.008	0.04	0.003<	0.009	418.0	7.100	0.320	3.60

B.O.W./ SITE: LAKE ONTARIO
SAMPLE POINT: CENTER ISLAND TRANSECT
STATION ID: 000006-00-01-1536

LAT: 43 36 21.00 LONG: 079 23 15.00 U T M: 17 0630138.1 4829142.6 9 REGION: 03

SAMPLE DATE YYMMDD	HOUR LMT	STN DIST MTRS	SAMP NO.	ASUT ARSENIC UNF.TOT. MG/L AS AS	CDUT CADMIUM UNF.TOT. MG/L AS CD	CRUT CHROMIUM UNF.TOT. MG/L AS CR	HGUT MERCURY F.TOT. UG/L AS HG	PBUT LEAD UNF.TOT. MG/L AS PB	ZNUT ZINC UNF.TOT. MG/L AS ZN	COND25 CONDUCT. 25C UMHO/CM AT 25 C	NHTKUR K'DAHL N TOTAL FIL.TOT. MG/L AS N	PPUT PHOSPHOR UNF.TOT. MG/L AS P	TURB TURB'ITY FTU
840712	1640		60337	0.001<	0.0002<	0.002	0.01<	0.003<	0.002	335.0	0.280	0.014	1.75
			60338	0.001<	0.0002<	0.002	0.01	0.003<	0.002	336.0	0.330	0.012	1.11
			60339	0.001<	0.0002<	0.002	0.01<	0.003<	0.002	334.0	0.320	0.011	1.60
840725	1059		60428	0.001	0.0003<	0.002	0.01	0.003<	0.001<	326.0	0.280	0.005	1.34
			60430	0.001<	0.0003<	0.002	0.01<	0.003<	0.001<	325.0	0.310	0.010	1.11
			60432	0.001<	0.0002<	0.001<	0.01	0.003<	0.001<	327.0	0.460	0.013	1.32
841016	1544		50742	0.001<	0.0002<	0.002<	0.04	0.003<	0.001	315.0	0.330	0.017	1.65
			50743	0.001<	0.0002<	0.002<	0.05	0.003<	0.001	315.0	0.300	0.013	1.15
			50744	0.001<	0.0002<	0.005	0.04	0.003<	0.001	315.0	0.330	0.015	1.29
841127	1520		67029	0.001<	0.0002<	0.003	0.02	0.005	0.007	337.0	0.490	0.039	1.02
			67030	0.001<	0.0002<	0.003	0.02	0.004	0.006	335.0	0.470	0.043	1.92
			67031	0.001	0.0002<	0.003	0.01	0.004	0.006	335.0	0.430	0.033	1.48

B.O.M./ SITE: LAKE ONTARIO
SAMPLE POINT: EAST HEADLAND CELL #1

STATION ID: 000006-00-01-1984

0 LAT: 43 37 50.00 LONG: 079 20 32.00 U T M: 17 0633737.6 4831960.2 9 REGION: 03
0=INTERIM TEST-NAME: ASUT CDUT CRUT HGUT PBUT ZNUT COND25 NITKUR PPUT TURB

SAMPLE DATE YYMMDD	HOUR LMT	STN DIST MTRS	SAMP NO.	ARSENIC UNF.TOT. MG/L AS AS	CADMIUM UNF.TOT. MG/L AS CD	CHROMIUM UNF.TOT. MG/L AS CR	MERCURY F.TOT. UG/L AS HG	LEAD UNF.TOT. MG/L AS PB	ZINC UNF.TOT. MG/L AS ZN	CONDUCT. 25C UMHO/CM AT 25 C	K'DAHL N TOTAL FIL.TOT. MG/L AS N	PHOSPHOR UNF.TOT. MG/L AS P	TURB'ITY FTU
840712	1032		60307	0.001<	0.0002<	0.003	0.02	0.007	0.011	330.0	0.440	0.002	22.00
			60308	0.001<	0.0002<	0.004	0.01	0.009	0.012	331.0	0.460	0.001	21.00
			60309	0.001<	0.0002<	0.003	0.01<	0.007	0.011	331.0	0.460	0.004	22.00
840725	1327		60440	0.001<	0.0002<	0.002	0.01<	0.006	0.006	331.0	0.440	0.039	19.20
			60442	0.001	0.0002<	0.002	0.01	0.005	0.004	331.0	0.510	0.004	24.00
			60444	0.001	0.0002<	0.002	0.01<	0.005	0.006	331.0	0.440	0.036	19.40
841016	1413		50739	0.001<	0.0002<	0.004	0.04	0.006	0.010	330.0	0.470	0.005	14.80
			50740	0.001<	0.0002<	0.004	0.04	0.006	0.010	330.0	0.470	0.041	15.80
			50741	0.001<	0.0002<	0.006	0.05	0.006	0.011	330.0	0.440	0.040	15.30
841127	1418		67027	0.001<	0.0002<	0.002	0.02	0.003<	0.002	330.0	0.230	0.013	1.67
			67028	0.001	0.0002<	0.002	0.01	0.003<	0.001	330.0	0.230	0.013	1.38
			67029	0.001	0.0002<		0.02	0.003<	0.001	330.0	0.190	0.010	1.43

B.O.M./ SITE: LAKE ONTARIO
SAMPLE POINT: LANDFILL DUMPING SITE MOVEABLE

STATION ID: 000006-00-01-1987

0 LAT: 43 37 34.00 LONG: 079 19 24.00 U T M: 17 0635271.4 4831497.2 9 REGION: 03
0=INTERIM TEST-NAME: ASUT CDUT CRUT HGUT PBUT ZNUT COND25 NITKUR PPUT TURB

SAMPLE DATE YYMMDD	HOUR LMT	STN DIST MTRS	SAMP NO.	ARSENIC UNF.TOT. MG/L AS AS	CADMIUM UNF.TOT. MG/L AS CD	CHROMIUM UNF.TOT. MG/L AS CR	MERCURY F.TOT. UG/L AS HG	LEAD UNF.TOT. MG/L AS PB	ZINC UNF.TOT. MG/L AS ZN	CONDUCT. 25C UMHO/CM AT 25 C	K'DAHL N TOTAL FIL.TOT. MG/L AS N	PHOSPHOR UNF.TOT. MG/L AS P	TURB'ITY FTU
840712	1156		60316	0.001<	0.0002<	0.004	0.02	0.005	0.007	349.0	0.880	0.078	31.00
			60317	0.001<	0.0002<	0.003	0.01<	0.005	0.007	346.0	0.770	0.074	32.00
			60318	0.001<	0.0002<	0.003	0.01	0.006	0.010	340.0	0.630	0.062	24.00
840725	1310		60434	0.001	0.0002<	0.001<	0.01	0.003<	0.001<	329.0	0.350	0.016	3.30
			60436	0.001	0.0002<	0.002	0.01<	0.003<	0.004	330.0	0.340	0.026	19.50
			60438	0.001	0.0002<	0.002	0.01<	0.003<	0.001	328.0	0.350	0.031	31.00
841016	1217		50730	0.001<	0.0002<	0.003	0.04	0.003<	0.004	320.0	0.420	0.049	12.60
			50731	0.001<	0.0002<	0.004	0.04	0.004	0.004	315.0	0.440	0.045	17.60
			50732	0.001<	0.0002<	0.004	0.04	0.003<	0.005	319.0	0.440	0.046	13.20
841127	1236		67018	0.001	0.0002<	0.003	0.04	0.003<	0.005	342.0	0.450	0.040	4.80
			67019	0.001<	0.0002<	0.002	0.04	0.003<	0.003	340.0	0.770	0.053	1.58
			67020	0.001<	0.0002<	0.002	0.05	0.003<	0.001	335.0	0.460	0.040	7.60

B.O.M./ SITE: LAKE ONTARIO
SAMPLE POINT: TORONTO WATER FRONT EASTERLY CONTROL

STATION ID: 000006-00-01-1997

0 LAT: 43 40 39.00 LONG: 079 14 48.00 U T M: 17 0641336.2 4837332.4 9 REGION: 03
0=INTERIM TEST-NAME: ASUT CDUT CRUT HGUT PBUT ZNUT COND25 NITKUR PPUT TURB

SAMPLE DATE YYMMDD	HOUR LMT	STN DIST MTRS	SAMP NO.	ARSENIC UNF.TOT. MG/L AS AS	CADMIUM UNF.TOT. MG/L AS CD	CHROMIUM UNF.TOT. MG/L AS CR	MERCURY F.TOT. UG/L AS HG	LEAD UNF.TOT. MG/L AS PB	ZINC UNF.TOT. MG/L AS ZN	CONDUCT. 25C UMHO/CM AT 25 C	K'DAHL N TOTAL FIL.TOT. MG/L AS N	PHOSPHOR UNF.TOT. MG/L AS P	TURB'ITY FTU
840712	1434		60334	0.001<	0.0002<	0.002	0.01<	0.003<	0.001<	330.0	0.300	0.010	3.60
			60335	0.001<	0.0002<	0.002	0.01<	0.003<	0.001	330.0	0.330	0.010	2.70
			60336	0.001<	0.0002<	0.002	0.01	0.003<	0.001<	332.0	0.300	0.012	4.50
840725	1639		60488	0.001	0.0002<	0.001<	0.01<	0.003<	0.001<	331.0	0.290	0.012	3.60
			60490	0.001	0.0002<	0.001<	0.01<	0.003<	0.001	332.0	0.300	0.013	3.70
			60492	0.001<	0.0002<	0.001<	0.01<	0.003<	0.001<	331.0	0.310	0.014	2.30
		1720	60494	0.003	0.0002<	0.001<	0.01<	0.003<	0.010	3.4	0.020<T	0.001<N	1.53
841016	1012		50715	0.001<	0.0002<	0.003	0.05	0.003<	0.002	321.0	0.490	0.027	1.40
			50716	0.001<	0.0002<	0.003	0.03	0.003<	0.002	321.0	0.300	0.014	1.02
			50717	0.001<	0.0002<	0.003	0.03	0.003<	0.002	320.0	0.300	0.016	1.09
841127	0958		67000	0.001	0.0002<	0.002	0.04	0.003<	0.002	325.0	0.120	0.006	1.42
			67001	0.001	0.0002<	0.002	0.04	0.003<	0.002	325.0	0.140	0.008	1.17
			67002	0.001	0.0002<	0.002	0.04	0.003<	0.001	325.0	0.140	0.009	0.96

B.O.M./ SITE: LAKE ONTARIO
SAMPLE POINT: TORONTO WATER FRONT WESTERLY CONTROL

STATION ID: 000006-00-01-1998

0 LAT: 43 36 36.00 LONG: 079 23 55.00 U T M: 17 0629232.5 4829588.0 9 REGION: 03
0=INTERIM TEST-NAME: ASUT CDUT CRUT HGUT PBUT ZNUT COND25 NITKUR PPUT TURB

SAMPLE DATE YYMMDD	HOUR LMT	STN DIST MTRS	SAMP NO.	ARSENIC UNF.TOT. MG/L AS AS	CADMIUM UNF.TOT. MG/L AS CD	CHROMIUM UNF.TOT. MG/L AS CR	MERCURY F.TOT. UG/L AS HG	LEAD UNF.TOT. MG/L AS PB	ZINC UNF.TOT. MG/L AS ZN	CONDUCT. 25C UMHO/CM AT 25 C	K'DAHL N TOTAL FIL.TOT. MG/L AS N	PHOSPHOR UNF.TOT. MG/L AS P	TURB'ITY FTU
840712	1310		60340	0.001<	0.0002<	0.002	0.01<	0.003<	0.002	339.0	0.310	0.011	3.10
			60341	0.001<	0.0002<	0.001	0.01<	0.003<	0.001<	337.0	0.330	0.014	2.70
			60342	0.001<	0.0002<	0.002	0.01<	0.003<	0.002	338.0	0.320	0.016	1.96
840725	1028		60422	0.001<	0.0003<	0.002	0.01	0.003<	0.002	326.0	0.660	0.017	1.38
			60424	0.001	0.0003<	0.002	0.01<	0.003<	0.001	328.0	0.280	0.011	1.08
			60426	0.001	0.0003<	0.002	0.01<	0.003<	0.001<	327.0	0.320	0.009	1.12
841016	1611		50745	0.001<	0.0002<	0.002<	0.04	0.003<	0.001	315.0	0.460	0.029	1.46
			50746	0.001<	0.0002<	0.002<	0.04	0.003<	0.001	315.0	0.510	0.036	1.42
			50747	0.001<	0.0002<	0.002<	0.04	0.003<	0.001	320.0	0.440	0.026	1.05
841127	1542		67033	0.001	0.0002<	0.002	0.02	0.003<	0.002	330.0	0.240	0.013	1.75
			67034	0.001<	0.0002<	0.002	0.01	0.003<	0.002	332.0	0.200	0.016	1.52
			67035	0.001	0.0002<		0.02	0.003<	0.002	335.0	0.220	0.012	2.80

B.O.W./ SITE: LAKE ONTARIO
SAMPLE POINT: EAST HEAD LAND CONTROL-EAST
STATION ID: 000006-00-01-1999

0 LAT: 43 37 21.00 LONG: 079 19 18.00 U T M: 17 0635413.9 4831098.9 9 REGION: 03
0=INTERIM TEST-NAME: ASUT CDUT CRUT HGUT PBUT ZNUT COND25

SAMPLE DATE YYMMDD	HOUR LMT	STN DIST MTRS	SAMP NO.	ARSENIC UNF.TOT. MG/L AS AS	CADMIUM UNF.TOT. MG/L AS CD	CHROMIUM UNF.TOT. MG/L AS CR	MERCURY F.TOT. UG/L AS HG	LEAD UNF.TOT. MG/L AS PB	ZINC UNF.TOT. MG/L AS ZN	CONDUCT. 25C UMHO/CM AT 25 C	NITKUR K'DAHL N TOTAL FIL.TOT. MG/L AS N	PPUT PHOSPHOR UNF.TOT. MG/L AS P	TURB TURB'ITY FTU
840712	1156		60319	0.001<	0.0002<	0.002	0.01	0.003<	0.003	337.0	0.510	0.018	3.20
	1217		60320	0.001<	0.0002<	0.002	0.04	0.003<	0.002	337.0	0.530	0.016	4.40
			60321	0.001<	0.0002<	0.002	0.01	0.003<	0.003	336.0	0.500	0.018	9.90
840725	1430		60460	0.001<	0.0002<	0.001<	0.01<	0.003<	0.001<	336.0	0.550	0.012	2.50
			60462	0.001<	0.0002<	0.001<	0.01	0.003<	0.001<	336.0	0.580	0.014	2.30
			60458	0.001<	0.0002<	0.002	0.01<	0.003<	0.001<	331.0	0.390	0.013	2.90
841016	1154		50727	0.001<	0.0002<	0.003	0.04	0.003<	0.003	337.0	0.870	0.041	4.40
	1155		50728	0.001<	0.0002<	0.003	0.03	0.003<	0.003	340.0	0.980	0.042	4.50
			50729	0.001<	0.0002<	0.003	0.03	0.003<	0.004	340.0	0.960	0.038	4.30
841127	1212		67015	0.001<	0.0002<	0.003	0.04	0.003<	0.002	345.0	0.610	0.039	2.10
			67016	0.001<	0.0002<	0.003	0.04	0.003<	0.003	340.0	0.860	0.057	2.40
			67017	0.001<	0.0002<	0.003	0.05	0.003<	0.002	340.0	0.600	0.042	2.30

B.O.W./ SITE: LAKE ONTARIO
SAMPLE POINT: MOVEABLE STATION WITHIN 10M. RADIUS FROM THE DREDGE
STATION ID: 000006-00-01-2017

0 LAT: 43 38 42.00 LONG: 079 21 33.00 U T M: 17 0632338.9 4833537.3 9 REGION: 03
0=INTERIM TEST-NAME: ASUT CDUT CRUT HGUT PBUT ZNUT COND25

SAMPLE DATE YYMMDD	HOUR LMT	STN DIST MTRS	SAMP NO.	ARSENIC UNF.TOT. MG/L AS AS	CADMIUM UNF.TOT. MG/L AS CD	CHROMIUM UNF.TOT. MG/L AS CR	MERCURY F.TOT. UG/L AS HG	LEAD UNF.TOT. MG/L AS PB	ZINC UNF.TOT. MG/L AS ZN	CONDUCT. 25C UMHO/CM AT 25 C	NITKUR K'DAHL N TOTAL FIL.TOT. MG/L AS N	PPUT PHOSPHOR UNF.TOT. MG/L AS P	TURB TURB'ITY FTU
840724	1118		60416	0.001	0.0003<	0.004	0.01<	0.004	0.006	389.0	0.310	0.043	6.80
			60417	0.001	0.0003<	0.004	0.01<	0.004	0.005	412.0	0.610	0.039	10.30
			60418	0.001	0.0003<	0.003	0.01<	0.003<	0.005	401.0	0.570	0.036	7.60
841011	1112		50703	0.001<	0.0002<	0.006	0.03	0.006	0.012	427.0	1.130	0.074	19.70
			50704	0.001<	0.0002<	0.005	0.05	0.005	0.010	425.0	1.120	0.071	22.00
			50705	0.001<	0.0002<	0.006	0.02	0.007	0.011	425.0	1.110	0.072	17.00

B.O.W./ SITE: LAKE ONTARIO
SAMPLE POINT: MOUTH OF CELL #2 AT THE EAST HEADLAND
STATION ID: 000006-00-01-2018

0 LAT: 43 37 37.00 LONG: 079 19 39.00 U T M: 17 0634933.3 4831583.0 9 REGION: 03
0=INTERIM TEST-NAME: ASUT CDUT CRUT HGUT PBUT ZNUT COND25

SAMPLE DATE YYMMDD	HOUR LMT	STN DIST MTRS	SAMP NO.	ARSENIC UNF.TOT. MG/L AS AS	CADMIUM UNF.TOT. MG/L AS CD	CHROMIUM UNF.TOT. MG/L AS CR	MERCURY F.TOT. UG/L AS HG	LEAD UNF.TOT. MG/L AS PB	ZINC UNF.TOT. MG/L AS ZN	CONDUCT. 25C UMHO/CM AT 25 C	NITKUR K'DAHL N TOTAL FIL.TOT. MG/L AS N	PPUT PHOSPHOR UNF.TOT. MG/L AS P	TURB TURB'ITY FTU
840712	1053		60310	0.001<	0.0002<	0.002	0.01	0.003<	0.003	330.0	0.360	0.024	6.20
			60311	0.001<	0.0002<	0.006	0.01<	0.003<	0.003	329.0	0.340	0.020	2.80
			60312	0.001<	0.0002<	0.002	0.01<	0.003<	0.003	332.0	0.330	0.024	6.70
840725	1340		60446	0.001	0.0002<	0.001	0.01<	0.003<	0.001<	328.0	0.330	0.013	4.80
			60448	0.001<	0.0002<	0.001	0.01<	0.003<	0.001<	331.0	0.350	0.015	4.30
			60450	0.001<	0.0002<	0.001	0.01<	0.003<	0.001<	330.0	0.360	0.017	4.10
841016	1353		50736	0.001<	0.0002<	0.003	0.04	0.003<	0.002	327.0	0.350	0.017	3.20
			50737	0.001<	0.0002<	0.003	0.05	0.003<	0.004	325.0	0.380	0.028	3.60
			50738	0.001<	0.0002<	0.003	0.04	0.003<	0.004	325.0	0.340	0.017	2.70
841127	1343		67024	0.001	0.0002<	0.002	0.02	0.003<	0.003	335.0	0.260	0.014	4.80
			67025	0.001<	0.0002<	0.002	0.01	0.003<	0.003	335.0	0.260	0.017	4.10
			67026	0.001<	0.0002<	0.002	0.01	0.003<	0.003	335.0	0.280	0.016	6.30

B.O.W./ SITE: LAKE ONTARIO
SAMPLE POINT: LOWER DON RIVER BELOW EASTERN AVENUE
STATION ID: 000006-00-01-2020

0 LAT: 43 39 17.00 LONG: 079 21 04.00 U T M: 17 0632967.1 4834629.9 9 REGION: 03
0=INTERIM TEST-NAME: ASUT CDUT CRUT HGUT PBUT ZNUT COND25

SAMPLE DATE YYMMDD	HOUR LMT	STN DIST MTRS	SAMP NO.	ARSENIC UNF.TOT. MG/L AS AS	CADMIUM UNF.TOT. MG/L AS CD	CHROMIUM UNF.TOT. MG/L AS CR	MERCURY F.TOT. UG/L AS HG	LEAD UNF.TOT. MG/L AS PB	ZINC UNF.TOT. MG/L AS ZN	CONDUCT. 25C UMHO/CM AT 25 C	NITKUR K'DAHL N TOTAL FIL.TOT. MG/L AS N	PPUT PHOSPHOR UNF.TOT. MG/L AS P	TURB TURB'ITY FTU
840724	1330		60419	0.001	0.0006	0.017	0.01	0.011	0.026	990.0	4.400	0.205	16.60
			60420	0.001	0.0003<	0.017	0.01<	0.009	0.024	989.0	4.400	0.186	13.80
			60421	0.001	0.0003<	0.018	0.01<	0.010	0.025	991.0	4.500	0.350	15.90
841011	1300		50709	0.001<	0.0002<	0.015	0.04	0.006	0.015	920.0	4.600	0.106	6.20
			50710	0.001<	0.0002<	0.015	0.04	0.003<	0.013	925.0	3.900	0.128	4.30
			50711	0.001<	0.0002<	0.009	0.04	0.003<	0.009	925.0	3.750	0.106	5.60
841128	1200		67045	0.001<	0.0004	0.008	0.04	0.006	0.025	1027.0	1.450	0.395	6.30
			67046	0.001<	0.0003	0.008	0.04	0.006	0.024	1035.0	1.530	0.385	5.10
			67047	0.001<	0.0003		0.04	0.007	0.023	1035.0	1.460	0.390	9.70

B.O.W./ SITE: LAKE ONTARIO — STATION ID: 000006-00-01-2029
SAMPLE POINT: WESTERN INTAKE OF R.C. HARRIS PLANT
0 LAT: 43 40 07.00 LONG: 079 15 05.00 U T M: 17 0640976.4 4836337.1 9 REGION: 03
0=INTERIM TEST-NAME: ASUT CDUT CRUT HGUT PBUT ZNUT COND25 NNTKUR K'DAHL N PPUT TURB

SAMPLE DATE YYMMDD	HOUR LMT	STN DIST MTRS	SAMP NO.	ARSENIC UNF.TOT. MG/L AS AS	CADMIUM UNF.TOT. MG/L AS CD	CHROMIUM UNF.TOT. MG/L AS CR	MERCURY F.TOT. UG/L AS HG	LEAD UNF.TOT. MG/L AS PB	ZINC UNF.TOT. MG/L AS ZN	CONDUCT. 25C UMHO/CM AT 25 C	TOTAL FIL.TOT. MG/L AS N	PHOSPHOR UNF.TOT. MG/L AS P	TURB'ITY FTU
840712	1411		60331	0.001<	0.0002<	0.001	0.01<	0.003<	0.002	331.0	0.340	0.010	2.30
			60332	0.001<	0.0002<	0.002	0.01	0.003<	0.001	331.0	0.310	0.010	2.70
			60333	0.001<	0.0002<	0.001	0.01<	0.003<	0.001	331.0	0.320	0.010	4.10
840725	1612		60482	0.001	0.0002<	0.001<	0.01<	0.003<	0.001<	330.0	0.320	0.013	1.41
			60484	0.001	0.0002<	0.001<	0.01<	0.003<	0.001<	329.0	0.330	0.010	1.61
			60486	0.001	0.0002<	0.001<	0.01<	0.003<	0.001<	329.0	0.300	0.012	1.70
841016	0946		50712	0.001<	0.0002<	0.003	0.05	0.003<	0.002	320.0	0.310	0.019	0.78
			50713	0.001<	0.0002<	0.003	0.04	0.003<	0.004	320.0	0.280	0.014	1.74
			50714	0.001	0.0002<	0.003	0.04	0.003<	0.002	320.0	0.270	0.013	1.10
841127	1019		67003	0.001	0.0002<	0.002	0.03	0.003<	0.003	325.0	0.120	0.008	1.22
			67004	0.001<	0.0002<	0.002	0.05	0.003<	0.001	325.0	0.120	0.008	1.66
			67005	0.001<	0.0002<	0.002	0.04	0.003<	0.001	325.0	0.120	0.007	1.54

B.O.W./ SITE: LAKE ONTARIO — STATION ID: 000006-00-01-2307
SAMPLE POINT: EAST HEAD LAND CONTROL-WEST
0 LAT: 43 36 50.00 LONG: 079 19 50.00 U T M: 17 0634716.0 4830128.0 9 REGION: 03
0=INTERIM TEST-NAME: ASUT CDUT CRUT HGUT PBUT ZNUT COND25 NNTKUR K'DAHL N PPUT TURB

SAMPLE DATE YYMMDD	HOUR LMT	STN DIST MTRS	SAMP NO.	ARSENIC UNF.TOT. MG/L AS AS	CADMIUM UNF.TOT. MG/L AS CD	CHROMIUM UNF.TOT. MG/L AS CR	MERCURY F.TOT. UG/L AS HG	LEAD UNF.TOT. MG/L AS PB	ZINC UNF.TOT. MG/L AS ZN	CONDUCT. 25C UMHO/CM AT 25 C	TOTAL FIL.TOT. MG/L AS N	PHOSPHOR UNF.TOT. MG/L AS P	TURB'ITY FTU
840712	1114		60313	0.001<	0.0002<	0.002	0.01<	0.003<	0.002	329.0	0.240	0.009	1.19
			60314	0.001<	0.0002<	0.002	0.01<	0.003<	0.006	328.0	0.250	0.009	1.68
			60315	0.001<	0.0002<	0.002	0.01<	0.003<	0.001	328.0	0.250	0.010	1.65
840725	1401		60452	0.001<	0.0002<	0.001<	0.01<	0.003<	0.001<	328.0	0.350	0.011	2.50
			60454	0.001	0.0002<	0.002	0.01<	0.003<	0.004	330.0	0.330	0.010	3.30
			60456	0.001<	0.0002<	0.002	0.01<	0.003<	0.003	331.0	0.360	0.020	3.40
841016	1236		50733	0.001<	0.0002<	0.003	0.07	0.003<	0.002	330.0	0.500	0.023	4.80
			50734	0.001<	0.0002<	0.003	0.04	0.003<	0.002	330.0	0.480	0.019	4.80
			50735	0.001<	0.0002<	0.003	0.05	0.003<	0.002	330.0	0.510	0.022	3.90
841127	1326		67021	0.001<	0.0002<	0.002	0.04	0.003<	0.001	330.0	0.160	0.009	1.53
			67022	0.001<	0.0002<	0.002	0.03	0.003<	0.002	328.0	0.180	0.011	1.05
			67023	0.001<	0.0002<	0.002	0.01	0.003<	0.001<	330.0	0.180	0.011	1.37

B.O.W./ SITE: LAKE ONTARIO — STATION ID: 000006-00-01-2308
SAMPLE POINT: EAST HEADLAND TO MAIN STP TRANSECT
0 LAT: 43 37 58.00 LONG: 079 19 05.00 U T M: 17 0635682.2 4832246.2 9 REGION: 03
0=INTERIM TEST-NAME: ASUT CDUT CRUT HGUT PBUT ZNUT COND25 NNTKUR K'DAHL N PPUT TURB

SAMPLE DATE YYMMDD	HOUR LMT	STN DIST MTRS	SAMP NO.	ARSENIC UNF.TOT. MG/L AS AS	CADMIUM UNF.TOT. MG/L AS CD	CHROMIUM UNF.TOT. MG/L AS CR	MERCURY F.TOT. UG/L AS HG	LEAD UNF.TOT. MG/L AS PB	ZINC UNF.TOT. MG/L AS ZN	CONDUCT. 25C UMHO/CM AT 25 C	TOTAL FIL.TOT. MG/L AS N	PHOSPHOR UNF.TOT. MG/L AS P	TURB'ITY FTU
840712	1247		60322	0.001<	0.0002<	0.002	0.01<	0.003<	0.003	337.0	0.530	0.021	4.40
			60323	0.001<	0.0002<	0.002	0.01<	0.003<	0.002	336.0	0.570	0.022	4.50
			60324	0.001<	0.0002<	0.002	0.02	0.003<	0.002	338.0	0.530	0.020	4.80
840725	1456		60464	0.001<	0.0002<	0.001<	0.01<	0.003<	0.001<	341.0	0.830	0.027	3.80
			60466	0.001	0.0002<	0.001<	0.01	0.003<	0.001<	340.0	0.770	0.021	2.30
			60468	0.001	0.0002<	0.001<	0.01<	0.003<	0.001<	339.0	0.740	0.020	3.70
841016	1133		50724	0.001<	0.0002<	0.003	0.04	0.003<	0.002	330.0	0.370	0.022	4.30
			50725	0.001<	0.0002<	0.003	0.05	0.003<	0.003	330.0	0.350	0.024	4.40
			50726	0.001<	0.0002<	0.003	0.04	0.003<	0.003	330.0	0.380	0.026	4.20
841127	1135		67012	0.001	0.0002<	0.003	0.05	0.003<	0.003	350.0	0.670	0.035	1.93
			67013	0.001<	0.0002<	0.003	0.05	0.003<	0.005	345.0	0.510	0.035	2.40
			67014	0.001<	0.0002<	0.002	0.04	0.003<	0.002	352.0	0.470	0.034	1.59

B.O.W./ SITE: LAKE ONTARIO — STATION ID: 000006-00-01-2309
SAMPLE POINT: EAST HEADLAND TO MAIN STP TRANSECT
0 LAT: 43 38 29.00 LONG: 079 19 02.00 U T M: 17 0635730.0 4833204.0 9 REGION: 03
0=INTERIM TEST-NAME: ASUT CDUT CRUT HGUT PBUT ZNUT COND25 NNTKUR K'DAHL N PPUT TURB

SAMPLE DATE YYMMDD	HOUR LMT	STN DIST MTRS	SAMP NO.	ARSENIC UNF.TOT. MG/L AS AS	CADMIUM UNF.TOT. MG/L AS CD	CHROMIUM UNF.TOT. MG/L AS CR	MERCURY F.TOT. UG/L AS HG	LEAD UNF.TOT. MG/L AS PB	ZINC UNF.TOT. MG/L AS ZN	CONDUCT. 25C UMHO/CM AT 25 C	TOTAL FIL.TOT. MG/L AS N	PHOSPHOR UNF.TOT. MG/L AS P	TURB'ITY FTU
840712	1306		60325	0.001	0.0002<	0.002	0.01<	0.003<	0.002	339.0	0.570	0.030	5.00
			60326	0.001<	0.0002<	0.002	0.01	0.003<	0.001	337.0	0.570	0.024	2.80
			60327	0.001<	0.0002<	0.002	0.01<	0.003<	0.001	336.0	0.530	0.021	3.60
840725	1520		60470	0.001	0.0002<	0.001<	0.01<	0.003<	0.001<	327.0	0.290	0.010	2.30
			60472	0.001	0.0002<	0.001<	0.01<	0.003<	0.001<	330.0	0.260	0.009	3.10
			60474	0.001	0.0002<	0.001<	0.01<	0.003<	0.001<	329.0	0.290	0.010	3.30
841016	1112		50721	0.001<	0.0002<	0.003	0.04	0.003<	0.002	325.0	0.330	0.022	8.40
			50722	0.001<			0.04			325.0	0.320	0.023	5.50
			50723	0.001<	0.0002<	0.003	0.04	0.003<	0.003	327.0	0.330	0.024	6.60
841127	1117		67009	0.001<	0.0002<	0.002	0.03	0.003<	0.002	340.0	0.520	0.029	1.42
			67010	0.001<	0.0002<	0.003	0.04	0.003<	0.002	327.0	0.460	0.029	2.04
			67011	0.001<	0.0002<	0.002	0.03	0.003<	0.001	335.0	0.440	0.028	1.57

APPENDIX D : RESULTS OF ANALYSIS -- SEDIMENT TRAP SUSPENDED PARTICULATES

LABEL: 1983/84 IWF SEDIMENT TRAP RESULTS

	STATION	($g/m^2/d$) FLUX	MEAN D(ϕ)	%cv	%LOI	TP.mg/g	TN.mg/g	Ag.ug/g	As.ug/g	Cd.ug/g	Cr.ug/g	Cu.ug/g	Hg.ug/g	Ni.ug/g	Pb.ug/g	Zn.ug/g	Fe ug/g
1	1536.	10.19	7.00	23.00	5.70	1.10	3.80	3.50	11.23	1.60	87.00	87.00	.38	34.00	85.00	240.00	23000.00
2	1536.	36.92	6.70	24.00	4.50	1.50	2.40	4.00	5.81	1.70	90.00	69.00	.3[illegible]	25.00	77.00	160.00	21000.00
3	1536.	183.98	6.50	26.00	5.60	1.50	2.30	2.50	6.39	1.80	82.50	80.50	.24	25.70	73.70	169.00	18700.00
1	1419.	42.02	6.30	28.00	5.70	3.20	4.40	10.20	3.08	1.80	60.00	41.00	.14	17.00	45.00	110.00	20000.00
2	1419.	217.72	6.30	27.00	3.50	1.50	1.40	4.50	3.64	1.10	190.00	80.00	.17	21.00	36.00	110.00	20000.00
3	1419.	777.93	6.00	27.00	3.50	1.20	1.00	2.50	3.53	.60	59.00	45.50	.11	19.50	31.00	87.00	20800.00
4	1419.	1026.20	5.40	36.00	1.60	1.00	.60	MISSING	3.03	.75	33.00	22.00	.05	10.00	17.00	48.00	16000.00
1	2029.	6.37	7.20	24.00	11.00	1.30	5.60	MISSING	7.36	2.10	87.00	120.00	.61	43.00	80.00	220.00	26000.00
2	2029.	17.82	7.20	25.00	7.10	1.30	3.90	1.50	5.64	1.30	57.00	67.00	.18	29.00	44.00	150.00	21000.00
3	2029.	49.65	7.20	23.00	8.00	1.30	2.40	1.50	5.75	1.02	26.50	53.00	.12	30.50	47.20	136.00	18600.00
4	2029.	250.82	4.30	54.00	3.20	.90	1.40	MISSING	4.48	.75	25.00	21.00	.07	11.00	20.00	58.00	14000.00
1	2104.	1078.40	5.20	33.00	1.10	.80	.50	1.00	3.01	.53	21.00	27.00	.11	11.00	92.00	100.00	14000.00
2	2171.	341.22	5.90	30.00	3.80	1.20	1.30	2.00	4.16	.62	55.00	47.00	.15	37.50	53.50	106.00	22000.00
3	2171.	832.67	4.60	45.00	2.30	.70	.50	MISSING	3.21	.70	24.00	19.00	.08	9.00	37.00	58.00	14000.00
1	2105.	5.09	MISSING	MISSING	9.00	1.30	4.10	MISSING	13.11	2.90	89.00	77.00	.37	34.00	99.00	220.00	23000.00
2	2105.	95.49	6.60	27.00	3.50	1.10	1.70	1.50	5.95	.59	55.00	40.00	.13	21.00	26.00	92.00	19000.00
3	2105.	171.88	6.50	24.00	4.00	1.20	1.40	2.00	5.54	.73	42.00	45.00	.16	25.80	37.50	112.00	21500.00
1	2106.	8.91	7.00	21.00	8.80	1.20	4.40	2.00	8.10	1.60	83.00	69.00	MISSING	27.00	74.00	160.00	19000.00
2	2106.	94.22	7.00	23.00	6.20	1.00	2.10	2.00	5.43	1.20	61.00	56.00	.15	28.00	44.00	130.00	22000.00
3	2106.	168.06	6.80	24.00	5.00	1.30	2.10	1.50	6.39	.70	34.00	52.00	.14	27.00	42.50	128.00	23400.00
1	2107.	2.55	MISSING	MISSING	MISSING	.90	3.00	MISSING	4.61	MISSING	MISSING	MISSING	.32	MISSING	MISSING	MISSING	MISSING
2	2107.	112.04	6.10	29.00	4.40	1.50	1.60	2.50	5.11	.78	53.00	47.50	.23	20.00	61.00	120.00	21200.00
3	2107.	439.25	4.90	44.00	3.00	.90	.80	1.00	4.12	1.10	38.00	34.00	.12	14.00	44.00	87.00	19000.00
1	2108.	64.93	MISSING	MISSING	3.30	.80	1.00	1.00	4.79	.02	26.00	33.00	.18	13.00	53.00	89.00	12000.00
2	2108.	44.56	7.00	20.00	4.40	1.10	1.90	1.50	6.39	.80	51.00	52.00	.23	24.00	93.00	140.00	22000.00
3a	2108.	609.86	6.40	28.00	2.20	1.00	.80	1.00	4.58	.72	39.00	39.00	.16	20.00	58.00	100.00	20000.00
1	2109.	5.09	MISSING	MISSING	MISSING	.60	.90	MISSING	3.22	MISSING	MISSING	MISSING	MISSING	MISSING	MISSING	MISSING	MISSING
2	2109.	122.23	6.90	22.00	4.40	1.10	1.90	2.00	5.64	1.20	64.00	57.00	.19	24.00	87.00	140.00	21000.00
3a	2109.	804.66	5.30	38.00	2.60	1.10	.90	1.00	3.74	.77	33.00	35.00	.14	15.00	59.00	94.00	16000.00
4	2109.	361.59	6.30	33.00	5.20	.90	.60	MISSING	5.46	1.20	38.00	34.00	.19	15.00	58.00	100.00	20000.00
1	2110.	26.74	6.60	24.00	7.80	1.40	5.20	2.50	12.80	1.80	67.00	71.00	.40	27.00	110.00	210.00	21000.00
2	2110.	67.48	5.90	39.00	5.90	1.30	3.10	2.50	6.50	1.60	59.00	56.00	.30	22.00	93.00	170.00	18000.00
3	2110.	86.58	6.80	27.00	6.50	1.30	2.50	3.00	5.64	2.02	70.50	66.50	.35	27.50	131.50	229.00	26200.00

APPENDIX E

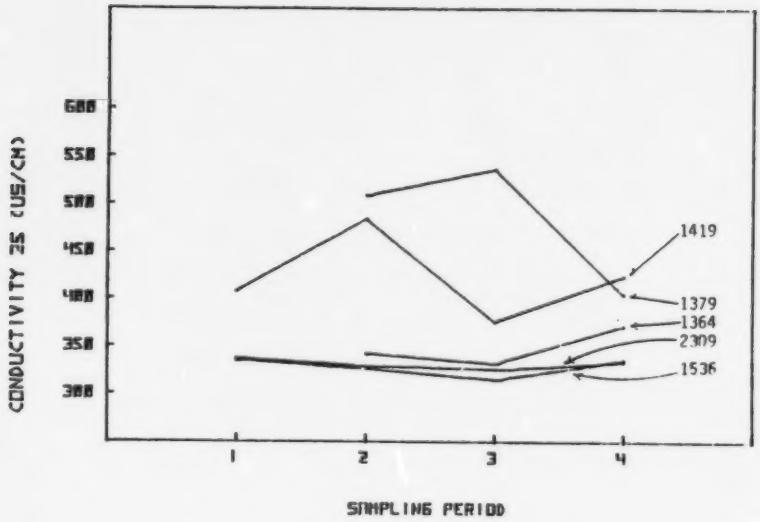
Profile Plots and Interaction of Station and Sampling Period Effects

Construction of profile plots using sample means for each sampling period at various stations provides a rapid means of visually inspecting the degree of interaction between station and sampling period effects for parameters of interest. In this case conductivity and total phosphorus results have been presented (Figure E1) for a range of station types (i.e. near inputs, near background, and in between) as an illustration.

If no interaction was present (i.e. sampling period had no effect on among-station differences or vice versa), then the difference in mean concentrations for these parameters would have been the same between stations over all sampling periods and the plotted lines (Figure E1) would have been parallel. A test on main effects (i.e. station on sampling period effects) would still have been meaningful, however, even if the difference in mean concentrations between stations had not been the same over all sampling periods, provided the interaction was orderly. For example, if the order of mean total phosphorus concentrations had been the same between stations, even though the magnitude of the differences changed from one sampling period to the next, then a test for station effects could have been appropriate. Such a case would have produced a profile plot with lines which, although not parallel, did not cross each other. This did not occur (Figure E1) and, consequently, a test for main effects would not have been meaningful.

REFERENCE

Ott, L. 1984: An Introduction to Statistical Methods and Data Analysis, Second Edition (Chapter 14). Duxbury Press, Boston.



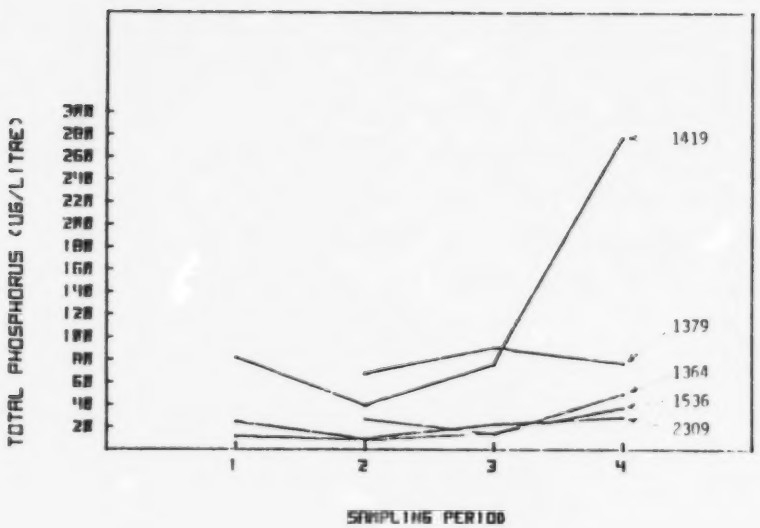


FIGURE E1: Profile Plots for Conductivity and Total Phosphorus at Selected Stations